

Module Manual

Master of Science

Mechatronics

Cohort: Winter Term 2016 Updated: 28th June 2017

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Program description

Content

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

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

Career prospects

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

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

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

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

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

Learning target

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

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

System Design

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

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

Intelligent Systems and Robotics

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

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

Program structure

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

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

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

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

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

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

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

- System design
- Intelligent systems and robotics.

Within each area of specialization 30 credits can be chosen form a module catalog containing modules with a size of six credits. Instead, open modules can be attend to the maximum extent of twelve credit points, in which smaller specialized courses can be combined, individually.

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

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



Core qualification

Iodule M0523: Business	& Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	 Students are able to find their way around selected special areas of management within the scope of business management. Students are able to explain basic theories, categories, and models in selected special areas of business management. Students are able to interrelate technical and management knowledge. Students are able to apply basic methods in selected areas of business management. Students are able to apply basic methods in selected areas of business management. Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence Social Competence Autonomy	• Students are 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
	None
-	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional 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 fully. Self-relia management, collaboration and professional and personnel management competences. The department implements these training obje its teaching architecture , in its teaching and learning arrangements , in teaching areas and by means of teaching offerings in which can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are p two different catalogues for nontechnical complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical a programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual development of competence provides orientation knowledge in the form of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semu view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to universi order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semester 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 dea interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 studen Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.
	The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.
	The Competence Level
	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differe reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scie theoretical level of abstraction in the B.Sc.
	This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership fur Bachelor's and Master's graduates in their future working life.
	Specialized Competence (Knowledge)
	Students can
	 explain specialized areas in context of the relevant non-technical disciplines, outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learnin different specialist disciplines relate to their own discipline and differentiate it as well as make connections, sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation 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.
Skille	Professional Competence (Skills)
OKIIS	
	In selected sub-areas students can
	 apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, to handle simple and advanced questions in aforementioned scientific disciplines in a successful manner, justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relation 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: Robotics					
Courses					
Title		Тур	Hrs/wk	CP	
Robotics: Modelling and Control (L0168)		Lecture	3	3	
Robotics: Modelling and Control (L1305)		Recitation Section (small)	2	3	
Module Responsible	Prof. Uwe Weltin				
Admission Requirements					
Recommended Previous	Fundamentals of electrical engineering				
Knowledge					
	Broad knowledge of mechanics				
	Fundamentals of control theory				
Educational Objectives	After taking part successfully, students have reached the follo	owing learning results			
Professional Competence					
Knowledge	Students are able to describe fundamental properties of robo	ts and solution approaches for multiple pro	oblems in robotics.		
Skills	Students are able to derive and solve equations of motion for	various manipulators.			
	Studente con generate trajectorias in variave seardinate avatame				
	Students can generate trajectories in various coordinate systems.				
	Students can design linear and partially nonlinear controllers	s for robotic manipulators.			
Personal Competence					
	Students are able to work applications and in small mixed around				
Autonomy	Students are able to work goal-oriented in small mixed group Students are able to recognize and improve knowledge defice				
Autonomy	Students are able to recognize and improve knowledge delic	ats independentily.			
	With instructor assistance, students are able to evaluate their	own knowledge level and define a further	course of study.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
	6				
Credit points	Written exam				
Examination					
Examination duration and scale	120 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering:				
Curricula	Computational Science and Engineering: Specialisation Sys		ompulsory		
	International Production Management: Specialisation Produc				
	International Management and Engineering: Specialisation I				
	International Management and Engineering: Specialisation I		ective Compulsory		
	Mechanical Engineering and Management: Core qualification	n: Compulsory			
	Mechatronics: Core qualification: Compulsory		leen		
	Product Development, Materials and Production: Specialisat		isory		
	Product Development, Materials and Production: Specialisat				
	Product Development, Materials and Production: Specialisat		mulaary		
	Theoretical Mechanical Engineering: Specialisation Product		mpuisory		
	Theoretical Mechanical Engineering: Technical Complemen	ary Course: Elective Compulsory			

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



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



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 Mech	anics II (Hydrostatics, Kinematics, Dynamics)		
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence		e lonowing rearing reads		
Knowledge		ing the derivation of the finite element metho	d and are able to	aivo an overview of
Kilowieuge	theoretical and methodical basis of the method.	ing the derivation of the linite element metho		give all overview of
	theoretical and methodical basis of the method.			
Skills	The students are capable to handle engineering proble	ms by formulating suitable finite elements, ass	embling the corresp	onding system matric
	and solving the resulting system of equations.	,		
Personal Competence				
Social Competence	-			
Autonomy	The students are able to independently solve challen	ging computational problems and develop ow	n finite element rou	itines. Problems can
	identified and the results are critically scrutinized.			
Maulda adia Harris	la des redent Otodo Time 404. Otodo Time in La store 50			
Workload in Hours				
Credit points				
Examination Examination duration and scale				
Assignment for the Following		~ .		
Curricula				
	Aircraft Systems Engineering: Specialisation Aircraft Sy Aircraft Systems Engineering: Specialisation Air Transp			
	Computational Science and Engineering: Specialisation Air Harsp			
	International Management and Engineering: Specialisato			
	International Management and Engineering: Specialisa		lective Compulsory	
	Mechatronics: Core qualification: Compulsory		coure computativ	
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective Compute	sorv	
	Biomedical Engineering: Specialisation Annicial Organ			
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techn Biomedical Engineering: Specialisation Management a			
	Product Development, Materials and Production: Core			
	Technomathematics: Specialisation III. Engineering Sci			
	Technomathematics: Specialisation III. Engineering Sci Technomathematics: Core qualification: Elective Comp			
	Theoretical Mechanical Engineering: Core qualification	•		
	mooreadar moonamear Engineering. Oure qualification	. comparisony		



Annual 10004. Finite Flamment Matheda		
Course L0291: Finite Element Met	noos	
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	WiSe	
Content	- General overview on modern engineering	
	- Displacement method	
	- Hybrid formulation	
	- Isoparametric elements	
	- Numerical integration	
	- Solving systems of equations (statics, dynamics)	
	- Eigenvalue problems	
	- Non-linear systems	
	- Applications	
	- Programming of elements (Matlab, hands-on sessions)	
	- Applications	
Literature	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin	

Course L0804: Finite Element Methods	
Тур	Recitation Section (large)
Hrs/wk	2
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 (L		Lecture	2	4
Control Systems Theory and Design (L		Recitation Section (small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	Introduction to Control Systems			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	ving learning results		
Professional Competence				
Knowledge	 Students can explain how linear dynamic systems are 	represented as state space models; the	y can interpret the s	ystem response to i
	states or external excitation as trajectories in state spa		,	,
	 They can explain the system properties controllabili 		nip to state feedba	ck and state estima
	respectively			
	They can explain the significance of a minimal realisa	ion		
	They can explain observer-based state feedback and	now it can be used to achieve tracking ar	id disturbance rejec	tion
	They can extend all of the above to multi-input multi-on	itput systems		
	They can explain the z-transform and its relationship v	ith the Laplace Transform		
	They can explain state space models and transfer func-			
	They can explain the experimental identification of AF	X models of dynamic systems, and how	the identification pr	oblem can be solve
	solving a normal equation			
	They can explain how a state space model can be cor	structed from a discrete-time impulse res	ponse	
Skills				
	Students can transform transfer function models into s			
	They can assess controllability and observability and observability and observability and observability and observable as a second			
	They can design LQG controllers for multivariable plan They can acres out a controller design both in contin		ad daaida which io	onnuonista fax a d
	 They can carry out a controller design both in contine sampling rate 	nuous-time and discrete-time domain, at	la decide which is	appropriate for a g
	 They can identify transfer function models and state sp 	ace models of dynamic systems from exr	perimental data	
	 They can carry out all these tasks using standard softw 			box Simulink)
Personal Competence				
Social Competence	Students can work in small groups on specific problems to an	ve at joint solutions.		
Autonomy	Students can obtain information from provided sources (lectu	re notes, software documentation, experi	ment guides) and u	se it when solving c
	problems.		0 ,	00
	They can assess their knowledge in weekly on-line tests and	hereby control their learning progress.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 min			
		lestive Compulson		
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: E Electrical Engineering: Core gualification: Compulsory	lective Compulsory		
Curricula	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Aircraft Systems	Compulsory		
	Computational Science and Engineering: Specialisation Systems		Compulsory	
	International Management and Engineering: Specialisation Usa			
	International Management and Engineering: Specialisation II.			
	Mechanical Engineering and Management: Specialisation Me			
	Mechatronics: Core qualification: Compulsory	······································		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective Compul	sory	
	Biomedical Engineering: Specialisation Implants and Endopr			
	Biomedical Engineering: Specialisation Medical Technology			
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective Compulso	iry	
	Product Development, Materials and Production: Core qualified	ation: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification: Com			



Тур	Lecture
	2
CP	4
	Independent Study Time 92, Study Time in Lecture 28
	Prof. Herbert Werner
Language	
	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



Module M1106: Vibration	Theory (GES)			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (GES) (L1423)		Lecture	2	3
Vibration Theory (GES) (L1433)		Recitation Section (large)	1	3
Module Responsible	Prof. Radoslaw Iwankiewicz			
Admission Requirements	Linear algebra, calculus, engineering/applied mechanics (espe	cially kinematics and kinetics)		
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the followi	ng learning results		
Professional Competence				
Knowledge	The primary purpose of the study of Vibration Theory is to dev predict and control vibrations, which is needed by the enginee	rs involved in the analysis and design		
	vehicles, aircraft, etc. The particular objectives of this course are			
	1. Analyse mechanical structures taking into account the effective structures taking into account the effective structures and structures are structures and structures are	fects of dynamic loads.		
	1. Appreciate the importance of vibration in structures and	mechanical devices.		
	2. Formulate and solve the equations of motion of mechan	ical systems.		
	Determine the natural frequencies and normal modes of comple	ex mechanical systems.		
Skills	At the end of this course the student should be able to:			
	 Develop simple mathematical models for vibration anal the dynamic response. 	ysis of complex systems; formulate an	d solve the equation	of motion to determi
	2. Carry out the linearization of equations of motion.			
	1. Determine natural frequencies and normal modes of mu	Ilti-degree-of-freedom and continuous	systems (rods, shafts	s. taut strings. beams)
	2. Carry out modal analysis to predict the dynamic respons	•		.,
	3. Analyse, in terms of eigenvalues, stability of time-invar	ant linear dynamic systems.		
Personal Competence				
Social Competence	Students can work in small groups and report on the findings.			
Autonomy	Students are able to solve the problems independently.			
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 hours: 2. MDOF systems: Newton- Euler and Lagrange's e	equations of motion. Linear systems:	eigenvalue problen	n, general solution a
	stability. Linear MDOF systems: free and forced vibrations. Cont		•	-
Assignment for the Following	Mechanical Engineering and Management: Specialisation Mecl			
Curricula	Mechatronics: Core qualification: Compulsory			
	Technomathematics: Specialisation III. Engineering Science: El	ective Compulsory		
	Technomathematics: Core qualification: Elective Compulsory			



Course L1423: Vibration Theory (GES)		
	Lecture	
Typ Hrs/wk		
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Radoslaw Iwankiewicz	
Language	EN	
Cycle	WiSe	
Content	SYSTEMS WITH FINITE NUMBER OF DEGREES OF FREEDOM (MULTI- DEGREE-OF-FREEDOM SYSTEMS)	
	1. Revision of the theory of single-degree-of-freedom systems.	
	 Equations of motion of a single rigid body and of multi-body systems: 2.1. Newton- Euler equations 	
	2.2. Lagrange's equations.	
	3.Linearization of equations of motion.	
	4.Linear equations of motion in a state-space form. Transformation of coordinates.	
	5.Linear systems: eigenvalue problem (eigenvalues and eigenvectors).	
	6. General solution for time-invariant linear systems and stability of those systems.	
	7. Linear systems: eigenvalue problem, free vibrations, natural frequencies, normal	
	modes (mode shapes).	
	8. Forced vibrations of linear systems.	
	LINEAR CONTINUOUS SYSTEMS:	
	9. Longitudinal vibrations of a rod and torsional vibrations of a shaft:	
	9.1. Eigenvalue problem, free vibrations, natural frequencies, normal	
	modes (mode shapes). 9.2. Forced vibrations.	
	10. Transverse vibrations of a beam and of a taut string: 10.1. Eigenvalue problem, free vibrations, natural frequencies, normal	
	modes (mode shapes).	
	10.2. Forced vibrations.	
Literature	1. S.S. Rao, Mechanical Vibrations, Addison-Wesley, 3rd edition, 1995.	
	2. C.F. Beards, Engineering Vibration Analysis with Application to Control Systems, Edward Arnold, 1995.	
	3. M. Geradin, D.Rixen, Mechanical Vibrations. Theory and Application to Structural Dynamics, J. Wiley, 1994.	
	4. K. Klotter, Technische Schwingungslehre I, II, Springer Verlag, 1981.	
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Course L1433: Vibration Theory (GES)	
Тур	Recitation Section (large)
Hrs/wk	1
CP	3
Workload in Hours	Independent Study Time 76, Study Time in Lecture 14
Lecturer	Prof. Radoslaw Iwankiewicz
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Module M1222: Design and Implementation of Software Systems Courses Title СР Hrs/wk Тур Design and Implementation of Software Systems (L1657) Lecture 2 3 Laboratory Course Design and Implementation of Software Systems (L1658) 2 3 Module Responsible Dr. Sandro Schulze Admission Requirements None Recommended Previous - Imperativ programming languages (C, Pascal, Fortran or similar) Knowledge Simple data types (integer, double, char, boolean), arrays, if-then-else, for, while, procedure and function calls Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge Students are able to describe mechatronic systems and define requirements. Students are able to design and implement mechatronic systems. They are able to argue the combination of Hard- and Software and the Skills interfaces. Personal Competence Social Competence Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities and define task within the team. Autonomy Students are able to solve individually exercises related to this lecture with instructional direction. Students are able to plan, execute and summarize a mechatronic experiment. Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Credit points 6 Examination Written exam Examination duration and scale Assignment for the Following Mechatronics: Core qualification: Compulsory Curricula

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

Course L1658: Design and Implementation of Software Systems		
Тур	Laboratory 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 M0565: Mechatror	nic Systems			
Courses				
Title		Тур	Hrs/wk	СР
Electro- and Contromechanics (L0174)		Lecture	2	2
Electro- and Contromechanics (L1300)		Recitation Section (small)	1	2
Mechatronics Laboratory (L0196)		Laboratory	2	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	none			
Recommended Previous	Fundamentals of mechanics, electromechanics a	and control theory		
Knowledge				
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	Students are able to describe methods and calc	ulations to design, model, simulate and optimize mec	hatronic systems an	d can repeat methods to
	verify and validate models.			
Skills	Students are able to plan and execute mechatr	onic experiments. Students are able to model mech	atronic systems and	derive simulations and
	optimizations.			
Personal Competence				
Social Competence	Students are able to work goal-oriented in small	mixed groups, learning and broadening teamwork ab	ilities and define tas	k within the team.
Autonomy	Students are able to solve individually exercises	related to this lecture with instructional direction.		
	Students are able to plan, execute and summariz	ze a mechatronic experiment.		
Workload in Hours	Independent Study Time 110, Study Time in Lect	ture 70		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min.			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Airc	craft Systems: Elective Compulsory		
Curricula	Mechatronics: Core qualification: Compulsory			

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

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



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



Module M1211: Research	Project Mechatronics	
Courses		
Title	Typ Hrs/wk CP	
Module Responsible	Prof. Uwe Weltin	
Admission Requirements	none	
Recommended Previous	Subjects of the program of studies.	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students are able to demonstrate their detailed knowledge in the field of mechatronics engineering. They can exemplify the state of	
	technology and application and discuss critically in the context of actual problems and general conditions of science and society.	
	The students can develop solving strategies and approaches for fundamental and practical problems in mechatronics engineering. They may	
	apply theory based procedures and integrate safety-related, ecological, ethical, and economic view points of science and society.	
	Scientific work techniques that are used can be described and critically reviewed.	
Skills	The students are able to independently select methods for the project work and to justify this choice. They can explain how these methods relate to	
	the field of work and how the context of application has to be adjusted. General findings and further developments may essentially be outlined.	
Personal Competence		
Social Competence	The students are able to condense the relevance and the structure of the project work, the work steps and the sub-problems for the presentation	
	and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their colleagues.	
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This	
	includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the	
	progress of the work, and to accomplish results on the state of the art in science and technology.	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0	
Credit points	12	
Examination	Project (accord. to Subject Specific Regulations)	
Examination duration and scale	It. FSPO	
Assignment for the Following	Mechatronics: Core qualification: Compulsory	
Curricula		

Ξ

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.

Courses					
Title		Тур	Hrs/wk	CP	
Robotics and Navigation in Medicine (LC		Lecture	2	3	
Robotics and Navigation in Medicine (LC		Project Seminar	2	2	
Robotics and Navigation in Medicine (LC		Recitation Section (small)	1	1	
Module Responsible Admission Requirements	Prof. Alexander Schlaefer None				
Admission Requirements					
Recommended Previous	 principles of math (algebra, analysis/calc 				
Knowledge	 principles of main (algebra, analysis)cat principles of programming, e.g., in Java (
	 solid R or Matlab skills 	51 0++			
Educational Objectives	After taking part successfully, students have read	ched the following learning results			
Professional Competence					
Knowledge		ng systems in clinical contexts and illustrate systems			
	be evaluated with respect to collision detection a	and safety and regulations. Students can assess typ	ical systems regarding	design and limitations	
Skills	The students are able to design and evaluate na	avigation systems and robotic systems for medical ap	plications.		
	···· · ·······························	- · · · · · · · · · · · · · · · · · · ·			
Personal Competence					
Social Competence	The students discuss the results of other groups	, provide helpful feedback and can incoorporate feed	back into their work.		
,					
Autonomy	The students can reflect their knowledge and do	cument the results of their work. They can present th	e results in an approp	riate manner.	
Workload in Hours	Independent Study Time 110, Study Time in Lec	cture 70			
Credit points	6				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	Computer Science: Specialisation Intelligence E	Engineering: Elective Compulsory			
Curricula	Electrical Engineering: Specialisation Medical T	echnology: Elective Compulsory			
	Computational Science and Engineering: Speci	alisation Systems Engineering and Robotics: Electiv	e Compulsory		
	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
	Biomedical Engineering: Specialisation Manage	ement and Business Administration: Elective Computer	sory		
	Product Development, Materials and Production	: Specialisation Product Development: Elective Com	pulsory		
	Product Development, Materials and Production	: Specialisation Production: Elective Compulsory			
	Product Development, Materials and Production	: Specialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisa	tion Bio- and Medical Technology: Elective Compute	orv		



Course L0335: Robotics and Navig	gation 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	SoSe
Content	- kinematics
	- calibration
	- tracking systems
	- navigation and image guidance
	- motion compensation
	The seminar extends and complements the contents of the lecture with respect to recent research results.
Literature	Spong et al.: Robot Modeling and Control, 2005
	Troccaz: Medical Robotics, 2012
	Further literature will be given in the lecture.

Course L0338: Robotics and Navig	Course L0338: Robotics and Navigation 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	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0336: Robotics and Navigation 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	SoSe
Content	See interlocking course
Literature	See interlocking course



ysis: sequences, series, differentia	Typ Lecture Seminar Recitation Section (small) tions, least squares problems, eigenvalues, singular v ttion, integration eached the following learning results	Hrs/wk 2 1 1	CP 3 2 1	
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	Lecture Seminar Recitation Section (small) tions, least squares problems, eigenvalues, singular v tion, integration	2 1 1	3 2	
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	Lecture Seminar Recitation Section (small) tions, least squares problems, eigenvalues, singular v tion, integration	2 1 1	3 2	
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	Seminar Recitation Section (small) tions, least squares problems, eigenvalues, singular v ttion, integration	1	2	
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	Recitation Section (small) tions, least squares problems, eigenvalues, singular v ttion, integration	1		
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	tions, least squares problems, eigenvalues, singular v tion, integration		1	
ar Algebra: systems of linear equat ysis: sequences, series, differentia part successfully, students have rea	ation, integration	ralues		
ysis: sequences, series, differentia part successfully, students have re-	ation, integration	values		
ysis: sequences, series, differentia part successfully, students have re-	ation, integration	values		
ysis: sequences, series, differentia part successfully, students have re-	ation, integration	alues		
	ached the following learning results			
able to				
able to				
h and intervalate basis sensents a	f functional analysis (Hilbert analysis analysis)			
	of functional analysis (Hilbert space, operators),			
name and understand concrete approximation methods,				
e and explain basic stability theore				
iss spectral quantities, conditions r	numbers and methods of regularisation			
able to				
	lysis,			
regularisation methods.				
able to solve specific problems in	n groups and to present their results appropriately (e.g	. as a seminar present	ation).	
onte aro canablo of chocking their	r understanding of complex concepts on their own. T	how can specify open	questions provisely a	
 Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in celving them. 				
		al-oriented manner on	hard problems.	
t Study Time 124. Study Time in Le	ecture 56			
gineering: Specialisation Control	and Power Systems: Elective Compulsory			
nal Science and Engineering: Spec	cialisation Scientific Computing: Elective Compulsory			
		npulsory		
Mechanical Engineering: Technica				
	approximation methods, stability theorems, ute spectral quantities, regularisation methods. able to solve specific problems ir nts are capable of checking their where to get help in solving them nts have developed sufficient per Study Time 124, Study Time in Li gineering: Specialisation Control gineering: Specialisation Modelin al Science and Engineering: Specialisation Intelligent Syster matics: Specialisation I. Mathem lechanical Engineering: Specialis	stability theorems, ute spectral quantities, regularisation methods. able to solve specific problems in groups and to present their results appropriately (e.g. nts are capable of checking their understanding of complex concepts on their own. T where to get help in solving them. nts have developed sufficient persistence to be able to work for longer periods in a goa Study Time 124, Study Time in Lecture 56 gineering: Specialisation Control and Power Systems: Elective Compulsory gineering: Specialisation Modeling and Simulation: Elective Compulsory al Science and Engineering: Specialisation Scientific Computing: Elective Compulsory :: Specialisation Intelligent Systems and Robotics: Elective Compulsory matics: Specialisation I. Mathematics: Elective Compulsory lechanical Engineering: Specialisation Numerics and Computer Science: Elective Com-	approximation methods, stability theorems, ute spectral quantities, regularisation methods. able to solve specific problems in groups and to present their results appropriately (e.g. as a seminar present nts are capable of checking their understanding of complex concepts on their own. They can specify open where to get help in solving them. nts have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on I Study Time 124, Study Time in Lecture 56 gineering: Specialisation Control and Power Systems: Elective Compulsory gineering: Specialisation Modeling and Simulation: Elective Compulsory al Science and Engineering: Specialisation Scientific Computing: Elective Compulsory : Specialisation Intelligent Systems and Robotics: Elective Compulsory	



Course L0487: Approximation and	Stability
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	This course is about solving the following basic problems of Linear Algebra,
	 systems of linear equations, least squares problems, eigenvalue problems but now in function spaces (i.e. vector spaces of infinite dimension) by a stable approximation of the problem in a space of finite dimension. Contents: crash course on Hilbert spaces: metric, norm, scalar product, completeness crash course on operators: boundedness, norm, compactness, projections uniform vs. strong convergence, approximation methods applicability and stability of approximation methods, Polski's theorem
Literature	 Galerkin methods, collocation, spline interpolation, truncation convolution and Toeplitz operators crash course on C*-algebras convergence of condition numbers convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra regularisation methods (truncated SVD, Tichonov)
	 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 L0489: Approximation and	l Stability
Тур	Seminar
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0488: Approximation and Stability		
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Marko Lindner	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
Title		Тур	Hrs/wk	СР
Numerical Treatment of Ordinary Differe	ential Equations (L0576)	Lecture	2	3
Numerical Treatment of Ordinary Differe		Recitation Section (small)	2	3
Module Responsible	Prof. Blanca Ayuso Dios			
Admission Requirements	None			
Recommended Previous Knowledge	 Mathematik I, II, III für Ingenieurstudierende Technomathematiker Basic MATLAB knowledge 	(deutsch oder englisch) oder Analysis & Li	ineare Algebra I + I	l sowie Analysis III
Educational Objectives	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
•	Students are able to			
	 list numerical methods for the solution of ordinary differential equations and explain their core ideas, repeat convergence statements for the treated numerical methods (including the prerequisites tied to the underlying problem), explain aspects regarding the practical execution of a method.) problem),
Skills	Students are able to			
	 implement (MATLAB), apply and compare num to justify the convergence behaviour of numeric for a given problem, develop a suitable solutio and to critically evaluate the results. 	cal methods with respect to the posed problem	and selected algorithr	
Personal Competence				
Social Competence	Students are able to			
	 work together in heterogeneously composed theoretical foundations and support each other 			nd knowledge), expl
Autonomy	Students are capable			
	 to assess whether the supporting theoretical ar to assess their individual progess and, if neces 		ually or in a team,	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	6		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following	Bioprocess Engineering: Specialisation A - General Bi	oprocess Engineering: Elective Compulsory		
Curricula	Chemical and Bioprocess Engineering: Specialisation	Chemical Process Engineering: Elective Comp	oulsory	
	Chemical and Bioprocess Engineering: Specialisation	General Process Engineering: Elective Compu	ulsory	
	Electrical Engineering: Specialisation Control and Pow	ver Systems: Elective Compulsory		
	Electrical Engineering: Specialisation Modeling and Si	imulation: Elective Compulsory		
	Energy Systems: Core qualification: Elective Compulsory			
	Computational Science and Engineering: Specialisation	on Scientific Computing: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and F	Robotics: Elective Compulsory		
	Technomathematics: Specialisation I. Mathematics: Ele	ective Compulsory		
	Theoretical Mechanical Engineering: Core qualification			
	Process Engineering: Specialisation Chemical Proces	• • • •		
	Process Engineering: Specialisation Process Enginee	ring: Elective Compulsory		



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

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



Courses					
Title		Тур	Hrs/wk	СР	
Nonlinear Dynamics (L0702)		Lecture	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous					
Knowledge	Calculus				
	Linear Algebra				
	Engineering Mechanics				
Educational Objectives	After taking part successfully, students have reache	ed the following learning results			
Professional Competence					
Knowledge	Students are able to reflect existing terms and cond	cepts in Nonlinear Dynamics and to develop	and research new terms and	concepts.	
Skills	Students are able to apply existing methods and p	ocesures of Nonlinear Dynamics and to dev	elop novel methods and pro	cedures.	
Personal Competence					
Social Competence	Students can reach working results also in groups.				
Autonomy	Students are able to approach given research task	s individually and to identify and follow up no	ovel research tasks by thems	elves.	
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56			
Credit points	6				
Examination	Written exam				
Examination duration and scale	2 Hours				
Assignment for the Following	Aircraft Systems Engineering: Specialisation Aircraft	ft Systems: Elective Compulsory			
Curricula	Computational Science and Engineering: Speciality	sation Scientific Computing: Elective Comput	lsory		
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory				
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Elective (Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation Medical Te	•••			
	Biomedical Engineering: Specialisation Managem		ompulsory		
	Product Development, Materials and Production: C				
	Theoretical Mechanical Engineering: Core qualific				
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulsory			

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



Module M0803: Embedde				
Courses				
Title		Тур	Hrs/wk	CP
Embedded Systems (L0805)		Lecture	3	4
Embedded Systems (L0806)		Recitation Section (small)	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Computer Engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the for	llowing learning results		
Professional Competence				
Knowledge	Embedded systems can be defined as information process	ing systems embedded into enclosing prod	ducts. This course tea	ches the foundation
	such systems. In particular, it deals with an introduction ir	nto these systems (notions, common chara	acteristics) and their s	specification langua
	(models of computation, hierarchical automata, specificatio	n of distributed systems, task graphs, speci	fication of real-time a	pplications, translation
	between different models).			
	Another part covers the hardware of embedded systems: Sonsors, A/D and D/A converters, real-time capable communication hardware			
	embedded processors, memories, energy dissipation, reco	onfigurable logic and actuators. The cours	e also features an in	troduction into real-t
	operating systems, middleware and real-time scheduling.	Finally, the implementation of embedded	systems using hardw	vare/software co-des
	(hardware/software partitioning, high-level transformations	of specifications, energy-efficient realizati	ons, compilers for en	nbedded processors
	covered.			
Skills	After having attended the course, students shall be able to	p realize simple embedded systems. The	students shall realize	which relevant part
	technological competences to use in order to obtain a func			
	of computations and feasible techniques for system-level of		•	•
	risks exist.			i bystern debign spe
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a gr	oup and to procept the results accordingly		
Social Competence	Students are able to solve similar problems alone of in a gr	oup and to present the results accordingly.		
Autonomy	Students are able to acquire new knowledge from specific I	iterature and to associate this knowledge v	vith other classes.	
Westlesdistless	la den en deut Otradu Time 404. Otradu Time in La struct 50			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points Examination	6 Written exam			
Examination duration and scale	90 minutes, contents of course and labs			
Assignment for the Following		arl: Specialization Computer Science: Elec	ivo Compulson	
Assignment for the Pollowing Curricula	General Engineering Science (German program, 7 semester	, , , , , , , , , , , , , , , , , , , ,		
Curricula				
	Electrical Engineering: Core qualification: Elective Compute		and Computer and	
	General Engineering Science (English program, 7 semeste	, ,	ive Compulsory	
	Computational Science and Engineering: Core qualification			
	Mechatronics: Specialisation System Design: Elective Com			
	Mechatronics: Specialisation Intelligent Systems and Robo	tics: Elective Compulsory		

Course L0805: Embedded System	IS
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	SoSe
Content	 Introduction 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. 2nd Edition, Springer, 2012. Springer, 2012.



Course L0806: Embedded System	Course 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	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



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Courses				
Title		Тур	Hrs/wk	CP
Optimal and Robust Control (L0658)			2 2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	Control Systems Theory and Design			
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 follow	ng learning results		
Professional Competence				
Knowledge				
	Students can explain the significance of the matrix Ricc		ems.	
	They can explain the duality between optimal state feed They can explain hew the U2 and U infinity parme are up			
	 They can explain how the H2 and H-infinity norms are u They can explain how an LOC design problem can be for the second sec			
	 They can explain how an LQG design problem can be f They can explain how model uncertainty can be represed 			
	 They can explain how moder uncertainty can be represented. They can explain how - based on the small gain theory 		•	mance for an uncer
	plant.		s stability and penor	
	 They understand how analysis and synthesis conditions 	on feedback loops can be represented	l as linear matrix ine	aualities.
	- ,			1
Skills	 Students are capable of designing and tuning LQG con 	rollers for multivariable plant models		
	 They are capable of representing a H2 or H-infinity des 		d plant, and of using	standard software to
	for solving it.	9. p	- p.a, a o. o	
	 They are capable of translating time and frequency of 	Iomain specifications for control loops	into constraints on	closed-loop sensit
	functions, and of carrying out a mixed-sensitivity design			
	They are capable of constructing an LFT uncertainty mo	del for an uncertain system, and of desi	gning a mixed-objec	tive robust controlle
	They are capable of formulating analysis and synthesis	conditions as linear matrix inequalities	(LMI), and of using s	standard LMI-solvers
	solving them.			
	 They can carry out all of the above using standard softw 	are tools (Matlab robust control toolbox).	
Personal Competence				
	Students can work in small groups on specific problems to arriv	e at joint solutions		
Autonomy			e documentation) ar	nd use it to solve a
Autonomy	/ Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve gi problems.			
	P			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Ele	active Compulsory		
Curricula	Electrical Engineering: Specialisation Control and Power Syste			
ourrouid	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Aircraft Systems: I	Elective Compulsory		
	Computational Science and Engineering: Specialisation System	1 5	Compulsory	
	Mechatronics: Specialisation System Design: Elective Compute	• •		
	Mechatronics: Specialisation Intelligent Systems and Robotics:	•		
	Biomedical Engineering: Specialisation Artificial Organs and R		sory	
	Biomedical Engineering: Specialisation Implants and Endopros	theses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and	nd Control Theory: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and Busi	ness Administration: Elective Compulso	ory	
	Product Development, Materials and Production: Specialisation	Product Development: Elective Compu	ulsory	
	Product Development, Materials and Production: Specialisation	Production: Elective Compulsory		
	Product Development, Materials and Production: Specialisation	Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification: Elective	e Compulsory		
	Theoretical Mechanical Engineering: Technical Complementar	v Course: Elective Compulsory		



Course L0658: Optimal and Robus	t 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 Robus	Course L0659: Optimal and Robust Control	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
Title		Тур	Hrs/wk	CP
Automation and Simulation (L1525)		Lecture	3	3
Automation and Simulation (L1527)		Recitation Section (large)	2	3
Module Responsible	Prof. Günter Ackermann			
Admission Requirements	none			
Recommended Previous	BSc Mechanical Engineering or similar			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the for	ollowing learning results		
Professional Competence				
Knowledge	Students can describe the structure an the function of pro-	ocess computers, the corresponding compo	nents, the data tran	sfer via bus systems
	programmable logic computers .			
	They can describe the basich principle of a numeric simula	ation and the corresponding parameters		
		ation and the corresponding parameters.		
	Thy can explain the usual method to simulate the dynamic	behaviour of three-phase machines.		
Skills	Students can describe and design simple controllers using	g established methodes.		
	They are able to assess the basic characterisitcs of a give	automation system and to evaluate if it is a	dequate for a given	nlant
	They are able to assess the basic characteristics of a given		dequate for a given	piant.
	They can modell and simulate technical systems with resp	ect to their dynamical behaviour and can use	Matlab/Simulink fo	r the simulation.
	They are able to applay established methods for the caclu	lation of the dynamical behaviour of three-ph	ase machines	
Personal Competence				
	Teamwork in small teams.			
Autonomy				
, lotonomy	Students are able to identify the need of methocic analysises in the field of automation systems, to do these analysis in an adequate manner up to evaluate the results critically.			
	·····,			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Cabin System	ns: Elective Compulsory		
0002.0	Aircraft Systems Engineering: Specialisation Aircraft Syste			
	International Management and Engineering: Specialisatio		Elective Compulsor	v
	International Management and Engineering: Specialisatio			
	International Management and Engineering: Specialisatio	, , ,	lective Compulsory	
	Mechatronics: Specialisation System Design: Elective Cor		, ,	
	Mechatronics: Specialisation Intelligent Systems and Rob			
	Product Development, Materials and Production: Specialis		lsory	
	Product Development, Materials and Production: Specialis	sation Production: Elective Compulsory		
	Product Development, Materials and Production: Specialis			



Course L1525: Automation and Sir	mulation
Тур	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	Structure of automation systsems
	Aufbau von Automationseinrichtungen
	Structure and function of process computers and corresponding componentes
	Data transfer via bus systems
	Programmable Logic Computers
	Methods to describe logic sequences
	Prionciples of the modelling and the simulation of continous technical systems
	Practical work with an established simulation program (Matlab/Simulink)
	Simulation of the dynamic behaviour of a three-phase maschine, simulation of a mixed continous/discrete system on base of tansistion flow diagrams.
Literature	U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag
	R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag
	Färber: Prozessrechentechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag
	Einführung/Tutorial Matlab/Simulink - verschiedene Autoren

Course L1527: Automation and Si	burse L1527: Automation and Simulation	
Тур	Recitation Section (large)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Günter Ackermann	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
litle		Тур	Hrs/wk	СР
Systems Engineering (L1547)		Lecture	3	4
Systems Engineering (L1548)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached the for	llowing learning results		
Professional Competence				
Knowledge	Students are able to:			
	understand systems engineering process models, method	ds and tools for the development of complex	Systems	
	describe innovation processes and the need for technology	gy Management		
	$\boldsymbol{\cdot}$ explain the aircraft development process and the process	of type certification for aircraft		
	explain the system development process, including requi	rements for systems reliability		
	· identify environmental conditions and test procedures for	airborne Equipment		
	value the methodology of requirements-based engineering	g (RBE) and model-based requirements en	gineering (MBRE)	
Skills	Students are able to:			
	• plan the process for the development of complex Systems	;		
	• organize the development phases and development Task	S		
	assign required business activities and technical Tasks			
	apply systems engineering methods and tools			
Personal Competence				
Social Competence	Students are able to:			
Social Competence	understand their responsibilities within a development tea	and intograte themselves with their role i	n the overall process	
	· understand their responsibilities within a development tea	and megrate tremserves with their fole i	in the overall process	•
Autonomy	Students are able to:			
	• interact and communicate in a development team which h	as distributed tasks		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 Minutes			
Assignment for the Following	Aircraft Systems Engineering: Core qualification: Compulse	ory		
Curricula	International Management and Engineering: Specialisation	II. Aviation Systems: Elective Compulsory		
	International Management and Engineering: Specialisation		lective Compulsory	
	Mechatronics: Specialisation System Design: Elective Com			
	Mechatronics: Specialisation Intelligent Systems and Robo			
	Product Development, Materials and Production: Specialis			
	Product Development, Materials and Production: Specialis			
	Product Development, Materials and Production: Specialis			



Course L1547: Systems Engineer	ing
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

Course 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	



Module M1212: Technical Complementary Course for IMPMEC (according to Subject Specific Regulations)						
Courses						
Title	Typ Hrs/wk CP					
Module Responsible	Prof. Uwe Weltin					
Admission Requirements	None					
Recommended Previous	See selected module according to FSPO					
Knowledge						
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 1 SI O					
Autonomy	see selected module according to FSPO					
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0					
Credit points	6					
Examination	according to Subject Specific Regulations					
Examination duration and scale	It. FSPO					
Assignment for the Following	Mechatronics: Specialisation System Design: Elective Compulsory					
Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					



Module M1223: Selected Topics of Mechatronics (Alternative A: 12 LP)

Courses					
Title		Тур	Hrs/wk	CP	
Development Management for Mechatronics (L1512)		Lecture	2	3	
Fatigue & Damage Tolerance (L0310)		Lecture	2	3	
Microcontroller Circuits: Implementation in Hardware and Software (L0087)		Seminar	2	2	
Microsystems Technology (L0724)		Lecture	2	4	
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)		Problem-based Learning	3	3	
Process Measurement Engineering (L1077)		Lecture	2	3	
Process Measurement Engineering (L1083)		Recitation Section (large)	1	1	
Feedback Control in Medical Technology (L0664)		Lecture	2	3	
Six Sigma (L1130)		Lecture	2	3	
Reliability in Engineering Dynamics (L01	76)	Lecture	2	2	
Reliability in Engineering Dynamics (L1303)		Recitation Section (small)	1	2	
Module Responsible	Prof. Uwe Weltin				
Admission Requirements Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative E					
	selected.				
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the following the students have reached the following the students have reached the following the students have been students have	owing learning results			
Professional Competence					
Knowledge	 Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Students are qualified to connect different special fields with each other 				
Skills	 Students can apply specialized solution strategies and new scientific methods in selected areas Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches 				
Personal Competence					
Social Competence Autonomy		kills by autonomous election of courses.			
Workload in Hours	Depends on choice of courses				
Credit points	12				
Assignment for the Following	Mechatronics: Specialisation System Design: Elective Comp	oulsory			



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

Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe/SoSe	
Content		
Literature		



Course L0724: Microsystems Tecl	nnology			
Hrs/wk				
CP				
	* Independent Study Time 92, Study Time in Lecture 28			
	naepenaent study Time 92, study Time in Lecture 28 Mündliche Prüfung			
	•			
	0 min			
	rof. Hoc Khiem Trieu			
0 0	EN			
	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 (Hormal 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 etching) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etching) Surface Micromachining and alternative Techniques (sacrificial etching) Surface Micromachining and alternative Techniques (sacrificial etching) 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 (tarian based and stress based principle, capacitive readout, piezoresistivy, pressure sensor: piezoresistive, ecapacitive and fabrication process; coelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: coerating principle and fabrication process) Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, ANR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, coganic semiconductor gas sensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfituidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microse			
Litoroturo	M Madou: Fundamentals of Microfabrication CRC Press 2002			
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			



Typ	Problem-based Learning
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Projektarbeit
Examination duration and scale	ca. 10 Seiten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
	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 Skript zur Vorlesung Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008 Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011



Course L1077: Process Measuren	nent Engineering			
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28			
Examination Form	Mündliche 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 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	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Examination Form	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Prof. Roland Harig	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Course L0664: Feedback Control i	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 scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	 Taking an engineering point of view, the lecture is structured as follows. Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma			
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 scale	90 Minuten		
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 		
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008		



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

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



Module M1224: Selected Topics of Mechatronics (Alternative B: 6 LP)

Courses					
Title		Тур	Hrs/wk	СР	
Development Management for Mechatronics (L1512)		Lecture	2	3	
Fatigue & Damage Tolerance (L0310)		Lecture	2	3	
Microcontroller Circuits: Implementation in Hardware and Software (L0087)		Seminar	2	2	
Microsystems Technology (L0724)		Lecture	2	4	
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)		Problem-based Learning	3	3	
Process Measurement Engineering (L1077)		Lecture	2	3	
Process Measurement Engineering (L10)83)	Recitation Section (large)	1	1	
Feedback Control in Medical Technology	y (L0664)	Lecture	2	3	
Six Sigma (L1130)		Lecture	2	3	
Reliability in Engineering Dynamics (L01	76)	Lecture	2	2	
Reliability in Engineering Dynamics (L13	03)	Recitation Section (small)	1	2	
Module Responsible	Prof. Uwe Weltin				
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics	(Alternative A: 12 LP) or "Selected Topics of	f Mechatronics (Alte	rnative B: 6 LP)" can	
	selected.				
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge					
	Students are able to express their extended knowledge and discuss the connection of different special fields of			or application areas	
	mechatronics				
	 Students are qualified to connect different special field 	elds with each other			
01.11					
Skills Students can apply specialized solution strategies and new scientific methods in selected areas			3		
 Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches 				26	
Personal Competence					
Social Competence					
Autonomy					
	 Students are able to develop their knowledge and s 	kills by autonomous election of courses.			
Workload in Hours	Depends on choice of courses				
Workload in Hours Credit points					
	6	pulsory			

Course L1512: Development Mana	agement for Mechatronics
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 scale	30 Minuten
Lecturer	Dr. Daniel Steffen
Language	DE
Cycle	SoSe
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morgen Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme



Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 L0087: Microcontroller Cir	cuits: 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 scale	10 min. Vortrag + anschließende Diskussion
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	



Course L0724: Microsystems Tes	hnology
Course L0724: Microsystems Tech	
Typ Hrs/wk	
CP	
	Independent Study Time 92, Study Time in Lecture 28
	Mündliche Prüfung
	30 min
Lecturer	Prof. Hoc Khiem Trieu
0 0	
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching; with KOH/TMAH: theory, corner undercuting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering; plasma etching, RIE, Bosch process, CRF2 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: Sebeck effect and thermopile; modulating sensors: thermopile; modulating sensors: scelector, plazonesistive, pressure sensor: plezoresistive, radiometry, R sensor: thermopile and bolometer) Mechanical Sensors (galvanomagnetic sensors; pipunction, NTC and PTC; thermal anemometer, mass flow sensor; plezoresistive, acapacitive and tabrication process; accelerometer; plezoresistive, plezoelectric and capacitive; angular rate sensor: plerating principle and fabrication process; accelerometer; plezoresistive, niezoelectric and equative; and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, cranic semiconductor gas sensor, clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfuluidics and TAS (drives: thermal, electrostatic, piezo electric
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
Literature	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008



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



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

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



Course L0664: Feedback Control i	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 scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	Taking an engineering point of view, the lecture is structured as follows.
	 Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart
	Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma	
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 scale	90 Minuten
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008



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

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



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

Course L1740: Lab Cyber-Physica	Il Systems
Тур	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. 2nd Edition, Springer, 2012. Begleitende Foliensätze



Module M1302: Applied H	lumar	noid	Roboti	cs															
-																			
Courses																			
Title												Тур				Hrs/wk		CP	
Humanoid Robotics (L1794)	D ()											Problem	n-based Lea	arning		6		6	
Module Responsible			twerner																
Admission Requirements Recommended Previous Knowledge	•	Obje Introd	ct oriented duction to rol system nanics	control	l syste	ems		ıms an	nd dat	ta struct	ires								
Educational Objectives	After ta	aking p	oart succe	essfully,	, stude	ents h	nave re	eache	d the	followir	g learr	ning resu	lts						
Professional Competence Knowledge		Stude	ents can e	explain	huma	anoid	robots	s.											
	•	 Students can explain the basic concepts, relationships and methods of forward- and inverse kinematics Students learn to apply basic control concepts for different tasks in humanoid robotics. 																	
Skills		 Students can implement models for humanoid robotic systems in Matlab and C++, and use these models for robot motion or other tasks. They are capable of using models in Matlab for simulation and testing these models if necessary with C++ code on the real robot system. They are capable of selecting methods for solving abstract problems, for which no standard methods are available, and apply it successfully. 																	
Personal Competence Social Competence			ents can c can prov										idle feedb	ack on thei	ir own re	esults			
Autonomy	•					•							sources, a solve the		n into the	e context of	the lea	cture.	
Workload in Hours	Indep	enden	t Study Ti	me 96,	Study	/ Time	e in Le	cture #	84										
Credit points	6																		
Examination	Colloc	quium																	
Examination duration and scale																			
Assignment for the Following	Comp	outer So	cience: Sp	oecialis	ation I	Intelli	ligence	e Engi	ineeri	ing: Ele	tive Co	ompulsor	у						
Curricula	Comp	outation	nal Scienc	ce and E	Engine	eering	ng: Spe	ecialis	ation	System	s Engii	neering a	nd Roboti	cs: Elective	e Compi	ulsory			
	Mecha	atronic	s: Specia	lisation	Intelli	igent	Syster	ms an	id Rol	botics: E	lective	e Compul	sory						
	Theor	retical N	Mechanic	al Engir	neerin	ng: Sp	peciali	isation	n Bio-	and Me	dical T	Technolog	gy: Electiv	e Compuls	ory				
	Theor	retical I	Mechanic	al Engir	neerin	ng: Te	echnic	al Cor	mpler	mentary	Cours	e: Electiv	e Compuls	sory					

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



Module M1306: Control La	ıb C						
-							
Courses							
litle		Тур	Hrs/wk	CP			
Control Lab IX (L1836)		Laboratory Course	1	1			
Control Lab VII (L1834)		Laboratory Course	1	1			
Control Lab VIII (L1835)		Laboratory Course	1	1			
Module Responsible							
Admission Requirements	None						
Recommended Previous	State space methods						
Knowledge	LQG control						
	H2 and H-infinity optimal control						
	uncertain plant models and robust control						
	LPV control						
Educational Objectives	After taking part successfully, students have reached	the following learning results					
Professional Competence							
Knowledge							
Ŭ	Students can explain the difference between	validation of a control lop in simulation and expe	erimental validation				
Skills	Students are capable of applying basic syste	m identification tools (Matlab System Identifica	tion Toolbox) to identi	fy a dynamic model t			
	can be used for controller synthesis						
	• They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers						
	 They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers 						
	 They are capable of representing model uncertainty 	ertainty, and of designing and implementing a ro	bust controller				
	 They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain 						
	scheduled controllers			-			
Personal Competence							
Social Competence	Students can work in teams to conduct experi	ments and document the results					
. .							
Autonomy	 Students can independently carry out simulat 	ion studies to design and validate control loops					
		-					
Workload in Hours	Independent Study Time 48, Study Time in Lecture 4	2					
Credit points	3						
Examination	Colloquium						
Examination duration and scale							
Assignment for the Following	Mechatronics: Specialisation Intelligent Systems and						
Curricula	Mechatronics: Specialisation System Design: Elective	e Compulsory					

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

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



Module Manual M. Sc. "Mechatronics"

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



Courses				
Fitle		Тур	Hrs/wk	CP
Advanced Topics in Vibration (L1743)		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 co	ncepts of Advanced Vibrations and to develop and research new	terms and concepts.	
Skills	Students are able to apply existing methods and	procesures of Advanced Vibrations and to develop novel methods	and procedures.	
Personal Competence				
Social Competence	Students can reach working results also in group	IS.		
Autonomy	Students are able to approach given research tas	sks individually and 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			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Computational Science and Engineering: S	pecialisation Scientific Computing: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design	n: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System	tems and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Core of	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compulsory		

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



Module M0835: Humanoid	I Robotics					
Courses						
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk 2	CP 2		
Module Responsible	Prof. Herbert Werner	Seminar	2	2		
Admission Requirements	None					
Recommended Previous	None					
Knowledge						
Kilowieuge	 Introduction to control systems 					
	Control theory and design					
Educational Objectives	After taking part successfully, students have reach	ed the following learning results				
Professional Competence						
Knowledge						
	Students can explain humanoid robots.					
	 Students learn to apply basic control concernation 	epts for different tasks in humanoid robotics.				
Skills						
		d aspects of humanoid robotics, based on specifi	ed literature			
	 Students generalize developed results and present them to the participants Students practice to prepare and give a presentation 					
	• Students practice to prepare and give a pre					
Personal Competence						
Social Competence	• Otudante ere conchie of developing colutio	no in interdicciplinous teams and present them				
		ons in interdisciplinary teams and present them back and handle constructive criticism of their own	roculte			
			11650115			
Autonomy	Ctudente evoluete eduentages and drewbs	acks of different forms of presentation for apositis t	acks and calest the basi	toolution		
		acks of different forms of presentation for specific t cientific field, are able of introduce it and follow				
	scientific discussion develops		presentations of othe	a students, such that a		
Workload in Hours	Independent Study Time 32, Study Time in Lecture	e 28				
Credit points	2					
Examination	Presentation					
Examination duration and scale	30 min					
Assignment for the Following	Electrical Engineering: Specialisation Control and					
Curricula	Mechatronics: Specialisation Intelligent Systems a					
	Mechatronics: Specialisation System Design: Elec					
	Biomedical Engineering: Specialisation Artificial C	• •	pulsory			
	Biomedical Engineering: Specialisation Implants a					
	Biomedical Engineering: Specialisation Medical T		•			
	Biomedical Engineering: Specialisation Managem		ulsory			
	Theoretical Mechanical Engineering: Core qualific					
	Theoretical Mechanical Engineering: Technical Co	Simplementary Course: Elective Compulsory				

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



Module M0838: Linear and	Nonlinear System Identifikation			
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Identification	on (L0660)	Lecture	2	3
Module Responsible			_	-
Admission Requirements	Control Systems Theory and Design			
Recommended Previous				
Knowledge	 Classical control (frequency response, root locus) 	5)		
	State space methods			
	Discrete-time systems			
	Linear algebra, singular value decomposition			
	Basic knowledge about stochastic processes			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	• Chudents can evalain the several fremework of	the prediction error method and its any	lighting to a variaty of line	ar and nanlinear mod
	Students can explain the general framework of	the prediction error method and its app	dication to a variety of line	ar and nonlinear mod
	structures They can explain how multilayer perceptron netw 	vorks are used to model peplinear dypa	mice	
	They can explain now indulayer perception new They can explain how an approximate predictive			
	 They can explain how an approximate predictive They can explain the idea of subspace identificat 			
	• They can explain the idea of subspace identificat		in theory	
Skills				
	Students are capable of applying the predicition	error method to the experimental identi	fication of linear and nonlin	lear models for dynam
	systems			
	They are capable of implementing a nonlinear pr			
	They are capable of applying subspace algorithm They are capable of applying subspace algorithm			/stems
	 They can do the above using standard software t 	ools (Including the Matlab System Ident	incation looidox)	
Personal Competence				
Social Competence	Students can work in mixed groups on specific problems	to arrive at joint solutions.		
Autonomy	Students are able to find required information in source	an provided (lecture poten literature c	offware decumentation) a	ad upp it to polyo give
Autonomy	Students are able to find required information in sourc problems.	es provided (lecture notes, interature, s	onware documentation) a	to use it to solve give
	problems.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control and Powe	r Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Co			
	Biomedical Engineering: Specialisation Artificial Organs		ompulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Compulsory		
	Biomedical Engineering: Specialisation Management ar		mpulsory	
	Theoretical Mechanical Engineering: Core qualification:	Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory		

Course L0660: Linear and Nonline	ar System Identification		
Тур	Lecture		
Hrs/wk			
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 		



Courses Title Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666) Module Responsible Admission Requirements	Prof. Herbert Werner	Typ Laboratory Course Laboratory Course Laboratory Course Laboratory Course	Hrs/wk 1 1	CP 1
Title Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666) Module Responsible	Prof. Herbert Werner	Laboratory Course Laboratory Course Laboratory Course	1 1	CP 1
Control Lab I (L1093) Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666) Module Responsible	Prof. Herbert Werner	Laboratory Course Laboratory Course Laboratory Course	1 1	1
Control Lab II (L1291) Control Lab III (L1665) Control Lab IV (L1666) Module Responsible	Prof. Herbert Werner	Laboratory Course Laboratory Course	1	1
Control Lab III (L1665) Control Lab IV (L1666) Module Responsible	Prof. Herbert Werner	Laboratory Course		
Control Lab IV (L1666) Module Responsible	Prof. Herbert Werner			1
Module Responsible	Prof. Herbert Werner		1	1
Admission Requirements				
	•			
Recommended Previous Knowledge	 State space methods LQG control H2 and H-infinity optimal control uncertain plant models and robust cont 	rol		
	LPV control			
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence Knowledge	• Students can explain the difference between validation of a control lop in simulation and experimental validation			
Skills	 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation of H-infinity optimal controllers They are capable of representing model uncertainty, and of designing and implementing a robust controller They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV gain scheduled controllers 			
Personal Competence				
Social Competence	• Students can work in teams to conduct	experiments and document the results		
Autonomy	• Students can independently carry out si	imulation studies to design and validate control loop:	S	
Workload in Hours	Independent Study Time 64, Study Time in Lec	ture 56		
Credit points	4			
Examination	Colloquium			
Examination duration and scale				
Assignment for the Following	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory		
	Mechatronics: Specialisation System Design: E			
	Mechatronics: Specialisation Intelligent System			
	Theoretical Mechanical Engineering: Core qua			
	meoretical Mechanical Engineering: Technica	I Complementary Course: Elective Compulsory		

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



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

ourse L1665: Control Lab III	
Тур	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Antonio Mendez Gonzalez
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides

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



Module M1223: Selected Topics of Mechatronics (Alternative A: 12 LP)

Courses Fitte Development Management for Mechatroni Fatigue & Damage Tolerance (L0310) Microcontroller Circuits: Implementation in Microsystems Technology (L0724) Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (Six Sigma (L1130)	Hardware and Software (L0087) 5) with SysML/UML (L1551) 7) 3)	Typ Lecture Lecture Seminar Lecture Problem-based Learning Lecture Recitation Section (large)	Hrs/wk 2 2 2 2 3 2	CP 3 3 2 4
Jevelopment Management for Mechatroni Fatigue & Damage Tolerance (L0310) Microcontroller Circuits: Implementation in Microsystems Technology (L0724) Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (Hardware and Software (L0087) 5) with SysML/UML (L1551) 7) 3)	Lecture Lecture Seminar Lecture Problem-based Learning Lecture	2 2 2 2 3	3 3 2
Eatigue & Damage Tolerance (L0310) Microcontroller Circuits: Implementation in Microsystems Technology (L0724) Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (Hardware and Software (L0087) 5) with SysML/UML (L1551) 7) 3)	Lecture Seminar Lecture Problem-based Learning Lecture	2 2 2 3	3 2
Microcontroller Circuits: Implementation in Microsystems Technology (L0724) Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (5) with SysML/UML (L1551) 7) 3)	Seminar Lecture Problem-based Learning Lecture	2 2 3	2
Microsystems Technology (L0724) Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (5) with SysML/UML (L1551) 7) 3)	Lecture Problem-based Learning Lecture	2 3	
Model-Based Systems Engineering (MBSE Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (7) 3)	Problem-based Learning Lecture	3	4
Process Measurement Engineering (L107 Process Measurement Engineering (L108 Feedback Control in Medical Technology (7) 3)	Lecture		
Process Measurement Engineering (L108 Feedback Control in Medical Technology (3)			3
Feedback Control in Medical Technology (Recitation Section (Jarge)		3
	L0664)		1	1
Six Siama (1 1130)		Lecture	2	3
		Lecture	2	3
Reliability in Engineering Dynamics (L0176)	Lecture	2	2
Reliability in Engineering Dynamics (L1303)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics	(Alternative A: 12 LP) or "Selected Topics of	of Mechatronics (Alte	rnative B: 6 LP)" ca
s	elected.			
Recommended Previous	lone			
Knowledge				
-	fter taking part successfully, students have reached the foll	owing learning results		
Professional Competence		0		
Knowledge				
	 Students are able to express their extended knowledge and discuss the connection of different special fields or application area mechatronics Students are qualified to connect different special fields with each other 			
Skilis	 Students can apply specialized solution strategies and new scientific methods in selected areas Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches 			
Personal Competence Social Competence Autonomy	Students are able to develop their knowledge and si	vills by autonomous election of courses.		
Workload in Hours	Depends on choice of courses			
Credit points 1				
	- lechatronics: Specialisation System Design: Elective Comp	pulsory		
	lechatronics: Specialisation Intelligent Systems and Robot			



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

Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 L0087: Microcontroller Cir	rcuits: 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 scale	10 min. Vortrag + anschließende Diskussion
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	



Course L0724: Microsystems Tec	hnology		
	Lecture		
Hrs/wk			
CP			
	Independent Study Time 92, Study Time in Lecture 28		
Examination duration and scale	0 min		
Lecturer	rof. 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 and LECVD; screen printing) Elching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching: back sputtering, plasma etching, RIE, Bosch process, royo 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: piezoresistive, piezoelectric and capacitive; angular rate sensor: piezoresistive, capacitive and tabrication process; accelerometer; piezoresistive, piezoelectric and capacitive; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, capanic sensors; magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, flamedia probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Cl		
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	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Projektarbeit
Examination duration and scale	ca. 10 Seiten
Lecturer	Prof. Ralf God
Language	DE
Cycle	SoSe
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning
	about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a
	realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	• What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
Literature	- Skript zur Vorlesung
	- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011



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

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



Course L0664: Feedback Control i	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 scale		
Lecturer	Ulf Pilz, Prof. Olaf Simanski	
Language	DE	
Cycle	SoSe	
Content	 Taking an engineering point of view, the lecture is structured as follows. Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.	
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag	
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000	

Course L1130: Six Sigma		
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



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

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



Module M1224: Selected Topics of Mechatronics (Alternative B: 6 LP)

Title Typ Hrs/wk CP Development Management for Mechatronics (L1512) Lecture 2 3					
Development Management for Machatomics (L1512) Lecture 2 3 Fadjue & Damage Tolerance (L0310) Lecture 2 3 Microcontrole (Crouts: Implementation in Markware and Software (L067) Beninar 2 2 Microcontrole (Crouts: Implementation in Markware and Software (L067) Lecture 2 3 Microcontrole (Crouts: Implementation in Markware and Software (L067) Lecture 2 3 Process Measurement Engineering (L177) Lecture 2 3 Process Measurement Engineering (L108) Rectation Boction (Large) 1 1 Process Measurement Engineering (L108) Rectation Section (Large) 1 2 Process Measurement Engineering (L108) Rectation Section (Large) 1 2 Relability in Engineering Dynamics (L130) Lecture 2 3 Module Responsible Prof. Uwe Wetlin Lecture 2 2 Admission Requirement None Implementation and the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected Soft Alternative B: 6 LP)" can selected Fordessional Competence Knowledge Alternative and plus secessfully, students have reached the following learning results Fordessional Competence Students are able to express their extended knowledge and discu	Courses				
Failgue & Damage Tolerance (L0310) Lecture 2 3 Microcontolar Circuits: inelamentation in Hardware and Software (L087) Seminar 2 2 Microcontolar Circuits: inelamentation in Hardware and Software (L087) Seminar 2 3 Model Baased Systems: Engineering (MISE) with SystMUUML (L151) Problem hased Latarning 3 3 Process Measurement Engineering (L1083) Rotation Section (Large) 1 1 Process Measurement Engineering (L1083) Rotation Section (Large) 1 1 Relability in Engineering Dynamics (L175) Lecture 2 3 Relability in Engineering Dynamics (L175) Lecture 2 3 Relability in Engineering Dynamics (L175) Lecture 2 3 Relability in Engineering Dynamics (L175) Lecture 2 2 Rodule Responsible Prof. Uwe Wellin 1 2 Admission Requirements Only one of the modules "Selected Topics of Mechatronics (Alternative B: 6 LP)' can selected. 2 3 Professional Competence Knowledge After taking part successfully, students have reached the following learning results - Fordessional Competence Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Students are able to tran	Title		Тур	Hrs/wk	CP
More operations Seminar 2 2 More operations Lecture 2 4 More operations Problem-based Learning 3 3 Process Measurement Engineering (MBSE) with SysMLUML (L155') Problem-based Learning 2 3 Process Measurement Engineering (L1077) Lecture 2 3 Process Measurement Engineering (L108) Rectation Saction (large) 1 1 Process Measurement Engineering (L108) Lecture 2 3 Relation Medical Technology (L1066) Lecture 2 3 Relation Engineering Dynamics (L130) Rectation Saction (small) 1 2 Module Responsible Port. Uvee Wellin 2 3 Recommended Previous Knowledge None	Development Management for Mechatronics (L1512)		Lecture	2	3
Microsystems Technology (L0724) Lecture 2 4 Medice Reade Systems Engineering (MSES) with SysMLUML (L1551) Probem-hased Learning 3 3 Process Measurement Engineering (L1087) Lecture 2 3 Process Measurement Engineering (L1087) Rectation Section (arge) 1 1 Feedback Control In Medical Technology (L0664) Lecture 2 3 Reliability in Engineering Onnamics (L1077) Lecture 2 3 Reliability in Engineering Medical Technology Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. None Educational Objectives After taking part successfully, students have reached the following learning results Students are able to express their extended knowledge and discuss the connection of differen	Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Model-Based Systems Engineering (MBSE) with SysMLUML (L1551) Problem-based Learning 3 3 Process Massurement Engineering (L1077) Lecture 2 3 Process Massurement Engineering (L1083) Rocitation Section (targe) 1 1 Process Massurement Engineering (L1083) Lecture 2 3 So Sigma (L1130) Lecture 2 3 Relability in Engineering Dynamics (L0175) Lecture 2 2 Relability in Engineering Dynamics (L0175) Lecture 2 2 Relability in Engineering Dynamics (L0175) Lecture 2 2 Relability in Engineering Dynamics (L0175) Rectation Section (small) 1 2 Module Responsible Prof. Uwe Weltin 2 3 Recommended Previous None 5 6 LP)* can asidered. Professional Competence None Recommended Previous None	Microcontroller Circuits: Implementation	in Hardware and Software (L0087)	Seminar	2	2
Process Measurement Engineering (L1077) Lecture 2 3 Process Measurement Engineering (L1083) Reclation Section (large) 1 1 Process Measurement Engineering (L1083) Reclation Section (large) 1 1 Process Measurement Engineering (L1083) Lecture 2 3 Relability in Engineering Dynamics (L1076) Lecture 2 2 Module Responsibile Prof. Uwe Wethin 2 2 Recommended Previous Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None	Microsystems Technology (L0724)		Lecture	2	4
Process Measurement Engineering (L108) - 1 1 Feedback Control in Medical Technology (L106) - Lacture 2 3 Ski Sigma (L1108) - Lacture 2 2 2 Reliability in Engineering Dynamics (L333) - Reliation Section (small) 1 2 Module Responsibe 0 Reliability in Engineering Dynamics (L333) - Reliability in Engineering Professional Completerere Rinowledge and discuss the connection of different special fields with each other Skills - Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches - Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches - Students are able to develop their knowledge and skills by autonomous election of courses. Richard Completerere - Social Completerere - Students are able to tarsfer learned skills to new and unknown problems and can	Model-Based Systems Engineering (ME	3SE) with SysML/UML (L1551)	Problem-based Learning	3	3
Feedback Control in Medical Technology (L0664) Lecture 2 3 Six Sigment (L1130) Lecture 2 3 Reliability Engineering Dynamics (L133) Rectation Section (small) 1 2 Reliability Engineering Dynamics (L133) Prof. Uwe Wellin 1 2 Admission Requirement Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None None	Process Measurement Engineering (L1	077)	Lecture	2	3
Six Sigma (L1130) Lecture 2 3 Reliability in Engineering Dynamics (L0176) Lecture 2 2 Reliability in Engineering Dynamics (L1303) Rectation Section (small) 1 2 Module Responsible Port. Uwe Wellin 1 2 2 Admission Requirements Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None Image: Comparis (Comparis) Image: Comparis (Comparis) Image: Comparis (Comparis) Educational Objectives After taking part successfully, students have reached the following learning results Image: Comparis) Image: Comparis) Image: Comparis) Professional Competence Knowledge After taking part successfully, students have reached knowledge and discuss the connection of different special fields or application areas mechatronics Image: Comparis) Image: Comparis) Skills Students are qualified to connect different special fields with each other Skills Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches Image: Comparis) Personal Competence Social Competence Image: Comparis) Image: Comparis) Image: Comparis)	Process Measurement Engineering (L1	083)	Recitation Section (large)	1	1
Relability in Engineering Dynamics (L017) Lecture 2 2 Relability in Engineering Dynamics (L013) Poil. Uwe Wellin 1 2 Module Responsible Poil. Uwe Wellin Image: Display of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None Image: Display of the modules of the taking part successfully, students have reached the following learning results Image: Display of the taking part successfully, students have reached the following learning results Professional Competence Knowledge Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Skills Students are able to fourses Students are able to develop their knowledge and skills to new and unknown problems and can develop own solution approaches Personal Competence Students are able to develop their knowledge and skills by autonomous election of courses. Image: Display of the taking part successfully. Workload in Hour Depends on choice of courses Image: Display of the taking part successfully. Image: Display of the taking part successfully. Workload in Hour Students are able to develop their knowledge and skills by autonomous election of courses. Image: Display of the taking part successfully. Workload in Hour <t< td=""><td>Feedback Control in Medical Technolog</td><td>y (L0664)</td><td>Lecture</td><td>2</td><td>3</td></t<>	Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Reliability in Engineering Dynamics (L133) Relation Section (small) 1 2 Module Responsible Prof. Uwe Wettin Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None None Educational Objective Attertaking part successfully, students have reached the following learning results Image: Comparison of the modules are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Image: Comparison of Competence Social Competence Social Competence Autoronics Skitis - Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Skitis - Students are able to connect different special fields with each other Skitis - Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches Personal Competence Social Competence Autoronics - Students are able to develop their knowledge and skills by autonomous election of courses. Worklead in How Depends on choice of courses - Students are able to develop their knowledge and skills by autonomous election of courses. Credit points 6 - Students are able to accesses - Students are able to accesses Morklead in How Me	Six Sigma (L1130)		Lecture	2	3
Module Responsible Prof. Uwe Weltin Admission Requirements Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None Knowledge After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge • Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Skills • Students are qualified to connect different special fields with each other Skills • Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches Personal Competence • Students are able to develop their knowledge and skills by autonomous election of courses. Workload in Hours Depends on choice of courses • Students are able to develop their knowledge and skills by autonomous election of courses. Workload in Hours Depends on choice of courses • G • Students are able to develop their knowledge and skills by autonomous election of courses.	Reliability in Engineering Dynamics (L01	176)	Lecture	2	2
Admission Requirements Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can selected. Recommended Previous None Knowledge After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge • Students are able to express their extended knowledge and discuss the connection of different special fields or application areas mechatronics Skills • Students are qualified to connect different special fields with each other Skills • Students can apply specialized solution strategies and new scientific methods in selected areas Personal Competence Students are able to develop their knowledge and skills to new and unknown problems and can develop own solution approaches Personal Competence Students are able to develop their knowledge and skills by autonomous election of courses. Workload in Hours Depends on choice of courses G Modults of develop their special fields or system Design: Elective Compulsory	Reliability in Engineering Dynamics (L13	303)	Recitation Section (small)	1	2
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Workload in Hours Depends on choice of courses Credit points 6 Assignment for the Following Mechatronics: Specialisation System Design: Elective Compulsory	Autonomy				
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Credit points 6 Assignment for the Following Mechatronics: Specialisation System Design: Elective Compulsory	Workload in Hours	Depends on choice of courses			
Assignment for the Following Mechatronics: Specialisation System Design: Elective Compulsory		'			
	· ·		pulsory		
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Course L1512: Development Mana	agement for Mechatronics	
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 scale	30 Minuten	
Lecturer	Dr. Daniel Steffen	
Language	DE	
Cycle	SoSe	
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization 	
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morgen Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme 	



Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	



Course L0724: Microsystems Tec	hology	
	Lecture	
Typ Hrs/wk		
CP		
	4	
	Independent Study Time 92, Study Time in Lecture 28	
Examination Form		
Examination duration and scale		
Lecturer	Prof. Hoc Khiem Trieu	
0 0	EN	
-	WiSe	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Bacics, 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 KQHTMAH: theory, corner undercuring, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, Crop process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, sliction: 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; plezoresistive, capacitive and fabrication process; accelerometer; plezoresistive, plezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor; pl-FC, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic,	
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	Problem-based Learning		
Hrs/wk	3		
CP	3		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Examination Form	Projektarbeit		
Examination duration and scale	ca. 10 Seiten		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	SoSe		
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning		
	about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a		
	realistic hardware platform (e.g. Arduino®, Raspberry Pi®):		
	What is a model?		
	What is Systems Engineering?		
	Survey of MBSE methodologies		
	The modelling languages SysML /UML		
	Tools for MBSE		
	Best practices for MBSE		
	Requirements specification, functional architecture, specification of a solution		
	From model to software code		
	Validation and verification: XiL methods		
	Accompanying MBSE project		
Literature	- Skript zur Vorlesung		
	- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008		
	- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011		



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



Course L0664: Feedback Control in Medical Technology		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale		
Lecturer	Ulf Pilz, Prof. Olaf Simanski	
Language	DE	
Cycle	SoSe	
Content	 Taking an engineering point of view, the lecture is structured as follows. Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.	
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000	

Course L1130: Six Sigma	
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 scale	90 Minuten
Lecturer	Prof. Claus Emmelmann
Language	
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008



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

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



Module M0552: 3D Comp	uter Vision			
Courses				
Title		Tun	Hrs/wk	CP
3D Computer Vision (L0129)		Typ Lecture	2	3
3D Computer Vision (L0129)		Recitation Section (small)	2	3
Module Responsible	Prof. Rolf-Rainer Grigat			-
Admission Requirements	None			
Recommended Previous				
Knowledge	 Knowlege of the modules Digital Image Analysis and P 	attern Recognition and Data Compressi	on are used in the pr	ractical task
	Linear Algebra (including PCA, SVD), nonlinear opti	mization (Levenberg-Marquardt), basic	s of stochastics and	d basics of Matlab a
	required and cannot be explained in detail during the le	ecture.		
Educational Objectives	After taking part successfully, students have reached the follow	ring learning results		
Professional Competence		5 5		
Knowledge	Students can explain and describe the field of projective geom	etry.		
·				
Skills	Students are capable of			
	 Implementing an exemplary 3D or volumetric analysis t 	ask		
	Using highly sophisticated methods and procedures of	the subject area		
	Identifying problems and			
	Developing and implementing creative solution sugges	tions.		
	With assistance from the teacher students are able to link the c	ontents of the three subject areas (modu	iles)	
	Digital Image Analysis			
	Pattern Recognition and Data Compression			
	and			
	3D Computer Vision			
	in practical assignments.			
Personal Competence				
Social Competence	Students can collaborate in a small team on the practical re-	ealization and testing of a system to re	econstruct a three-d	imensional scene or
	evaluate volume data sets.			
Autonomy	Students are able to solve simple tasks independently with refe	arence to the contents of the lectures and	d the evercise sets	
Autonomy	closents are able to some simple tasks independently with tele		1 110 0 01010100 0010.	
	Students are able to solve detailed problems independently with	th the aid of the tutorial's programming t	ask.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	60 Minutes, Content of Lecture and materials in StudIP			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: El	ective Compulsory		
Curricula	Computational Science and Engineering: Specialisation Syste	ms Engineering and Robotics: Elective	Compulsory	
	Information and Communication Systems: Specialisation Com	munication Systems, Focus Signal Proce	ssing: Elective Com	pulsory
	Information and Communication Systems: Specialisation Sec	ure and Dependable IT Systems, Focu	s Software and Sigr	nal Processing: Electiv
	Compulsory			
	Mechanical Engineering and Management: Specialisation Me	chatronics: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics			
	Microelectronics and Microsystems: Specialisation Communication	ation and Signal Processing: Elective Co	mpulsory	

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



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



Courses				
Title		Тур	Hrs/wk	СР
Digital Image Analysis (L0126)		Lecture	4	6
Module Responsible	Prof. Rolf-Rainer Grigat			
Admission Requirements	k.A.			
Recommended Previous	System theory of one-dimensional signals (convolution and correlat	ion, sampling theory, interp	plation and decimation, F	ourier transform, line
Knowledge	time-invariant systems), linear algebra (Eigenvalue decomposition, S	VD), basic stochastics and s	statistics (expectation valu	es, influence of sam
	size, correlation and covariance, normal distribution and its paramete	rs), basics of Matlab, basics	in optics	
Educational Objectives	After taking part successfully, students have reached the following lea	rning roculte		
Professional Competence	Aller taking part successionly, students have reached the following lea			
	Students can			
, nonicago				
	Describe imaging processes			
	Depict the physics of sensorics			
	Explain linear and non-linear filtering of signals			
	Establish interdisciplinary connections in the subject area and Interpret offects of the most important closes of important elements			visal models
	 Interpret effects of the most important classes of imaging sense 	ors and displays using main	ematical methods and phy	vsical models.
Skills	Students are able to			
	Use highly sophisticated methods and procedures of the subjection and implement executive solution			
	Identify problems and develop and implement creative solutio	ns.		
	Students can solve simple arithmetical problems relating to the specif	ication and design of image	processing and image an	alysis systems.
	Students are able to assess different solution approaches in multidim	ensional decision-making ar	eas.	
	Students can undertake a prototypical analysis of processes in Matlat	р.		
Davagnal Compositoria				
Personal Competence Social Competence	κA			
Social Competence	<u>к</u> л.			
Autonomy	Students can solve image analysis tasks independently using the rele	evant literature.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
	Written exam			
	60 Minutes, Content of Lecture and materials in StudIP			
	Computer Science: Specialisation Intelligence Engineering: Elective	Compulsory		
	Electrical Engineering: Specialisation Information and Communicatio		sory	
	Electrical Engineering: Specialisation Medical Technology: Elective C	Compulsory		
	Computational Science and Engineering: Specialisation Systems Eng	gineering and Robotics: Elec	tive Compulsory	
	Information and Communication Systems: Specialisation Communication	tion Systems, Focus Signal	Processing: Elective Com	pulsory
	Information and Communication Systems: Specialisation Secure an	d Dependable IT Systems,	Focus Software and Sign	al Processing: Elec
	Compulsory			
	International Management and Engineering: Specialisation II. Information	tion Technology: Elective C	ompulsory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Election			
	Microelectronics and Microsystems: Specialisation Communication and		ve Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Court			
	Theoretical Mechanical Engineering: Specialisation Numerics and Co	omputer Science: Elective Co	ompulsory	



Course L0126: Digital Image Analy	/sis
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Rolf-Rainer Grigat
Language	EN
Cycle	WiSe
Content	 Image representation, definition of images and volume data sets, illumination, radiometry, multispectral imaging, reflectivities, shape from shading Perception of luminance and color, color spaces and transforms, color matching functions, human visual system, color appearance models imaging sensors (CMOS, CCD, HDR, X-ray, IR), sensor characterization(EMVA1288), lenses and optics spatio-temporal sampling (interpolation, decimation, aliasing, leakage, moiré, flicker, apertures) features (filters, edge detection, morphology, invariance, statistical features, texture) optical flow (variational methods, quadratic optimization, Euler-Lagrange equations) segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts) registration (distance and similarity, variational calculus, iterative closest points)
Literature	Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011 Wedel/Cremers, Stereo Scene Flow for 3D Motion Analysis, Springer 2011 Handels, Medizinische Bildverarbeitung, Vieweg, 2000 Pratt, Digital Image Processing, Wiley, 2001 Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989



Module M0623: Intelligent	Systems in Medicine			
incluie incozor intelligent				
Courses				
Title		Тур	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)		Lecture	2	3
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2
Intelligent Systems in Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous	 principles of math (algebra, analysis/calculus) 			
Knowledge	 principles of stochastics 			
	 principles of programming, Java/C++ and R/Matlab 			
	advanced programming skills			
Educational Objectives	After taking part successfully, students have reached the following lear	mina results		
Professional Competence	· · · · · · · · · · · · · · · · · · ·			
Knowledge	The students are able to analyze and solve clinical treatment planning	and decision support problems	using methods for se	arch, optimization, and
	planning. They are able to explain methods for classification and their		-	
	can compare different methods for representing medical knowledg	e. They can evaluate methods i	n the context of clir	ical data and explair
	challenges due to the clinical nature of the data and its acquisition and	I due to privacy and safety require	ements.	
01:11-	The shadow have size as a few set of stars and a destine set had a	· · · · · · · · · · · · · · · · · · ·	l and disting Theory of	
Skiiis	The students can give reasons for selecting and adapting methods based on actual patient data and evaluate the implemented methods.	or classification, regression, and	i prediction. They ca	an assess the methous
	based on actual patient data and evaluate the implemented methods.			
Personal Competence				
Social Competence	The students discuss the results of other groups, provide helpful feedb	ack and can incoorporate feedba	ick into their work.	
Autonomy	The students can reflect their knowledge and document the results of t	heir work. They can present the r	esults in an appropri	ate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Elective C	ompulsory		
Curricula	Electrical Engineering: Specialisation Medical Technology: Elective C	ompulsory		
	Computational Science and Engineering: Specialisation Systems Eng	ineering and Robotics: Elective C	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Electiv	e Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regener		sory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses			
	Biomedical Engineering: Specialisation Medical Technology and Con			
	Biomedical Engineering: Specialisation Management and Business A			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical		ý	
	Theoretical Mechanical Engineering: Technical Complementary Cours	se: Elective Compulsory		

Course L0331: Intelligent Systems	Course L0331: Intelligent Systems 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 Systems	purse 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 Systems	Course 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		Тур	Hrs/wk	CP
Industrial Process Automation (L0344)		Lecture	2	3
Industrial Process Automation (L0345)		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 reac	ned the following learning results		
Professional Competence				
Knowledge	The students can evaluate and assess disctrete	e event systems. They can evaluate properties o	f processes and expla	ain methods for proce
-	analysis. The students can compare methods for	or process modelling and select an appropriate r	nethod for actual prob	lems. They can discu
	scheduling methods in the context of actual prob	lems and give a detailed explanation of advantage	es and disadvantages	of different programmi
	methods.			
Skills	The students are able to develop and model p	ocesses and evaluate them accordingly. This inv	volves taking into acco	ount optimal schedulir
	understanding algorithmic complexity and impler	nentation using PLCs.		
Personal Competence				
Social Competence	The students work in teams to solve problems.			
Autonomy	The students can reflect their knowledge and doo	ument the results of their work.		
	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points				
Examination Examination duration and scale	Written exam 90 minutes			
Assignment for the Following	Bioprocess Engineering: Specialisation A - Gene		mulaan	
Curricula		ation Chemical Process Engineering: Elective Cor		
	Computer Science: Specialisation Intelligence Er	ation General Process Engineering: Elective Com	pulsory	
	Electrical Engineering: Specialisation Control and			
	Aircraft Systems Engineering: Specialisation Control and			
	, , , , , , , , , , , , , , , , , , , ,	lisation Systems Engineering and Robotics: Electiv	e Compulsorv	
		ation Production Technology: Elective Compulsory		
	International Management and Engineering: Spe			
	Mechanical Engineering and Management: Spec			
	Mechatronics: Specialisation Intelligent Systems			
		on Numerics and Computer Science: Elective Con	npulsory	
	Theoretical Mechanical Engineering: Technical C		· ·	
	Process Engineering: Specialisation Chemical P			



Course L0344: Industrial Process	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 Process	course L0345: Industrial Process 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	



Module M0677: Digital Sig	nal Processing and Digital Filters			
Courses				
Title		Тур	Hrs/wk	CP
Digital Signal Processing and Digital Filte	ers (L0446)	Lecture	3	4
Digital Signal Processing and Digital Filte	ers (L0447)	Recitation Section (large)	1	2
Module Responsible	Prof. Gerhard Bauch			
Admission Requirements	None			
Recommended Previous	 Mathematics 1.0 			
Knowledge	Mathematics 1-3			
	Signals and Systems Europerately of signal and system that	ary as well as random processes		
	Fundamentals of signal and system theo			
	 Fundamentals of spectral transforms (For 	purier series, Fourier transform, Laplace transform)		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	The students know and understand basic algo	prithms of digital signal processing. They are familiar	with the spectral tra	nsforms of discrete-tim
	signals and are able to describe and analyse	signals and systems in time and image domain. The	ey know basic structu	ires of digital filters ar
	can identify and assess important properties i	ncluding stability. They are aware of the effects cau	sed by quantization	of filter coefficients ar
	signals. They are familiar with the basics of a	daptive filters. They can perform traditional and para	metric methods of sp	ectrum estimation, als
	taking a limited observation window into accour	nt.		
Skills	The students are able to apply methods of digita	al signal processing to new problems. They can choos	se and parameterize	suitable filter striucture
	In particular, the can design adaptive filters according to the minimum mean squared error (MMSE) criterion and develop an efficient			
	implementation, e.g. based on the LMS or RLS algorithm. Furthermore, the students are able to apply methods of spectrum estimation and to take			
	the effects of a limited observation window into	account.		
Personal Competence				
Social Competence	The students can jointly solve specific problems	5.		
Autonomy		rmation from appropriate literature sources. They can	n control their level o	of knowledge during th
	lecture period by solving tutorial problems, softw	vare tools, clicker system.		
Workload in Hours	Independent Study Time 124, Study Time in Lea	cture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	Computer Science: Specialisation Intelligence	Engineering: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Information	on and Communication Systems: Elective Compulsory	1	
	Electrical Engineering: Specialisation Control a	nd Power Systems: Elective Compulsory		
	Computational Science and Engineering: Speci	ialisation Systems Engineering and Robotics: Elective	Compulsory	
	Information and Communication Systems: Spec	ialisation Communication Systems, Focus Signal Proc	cessing: Elective Com	pulsory
	Mechanical Engineering and Management: Spe	ecialisation Mechatronics: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System	s and Robotics: Elective Compulsory		



Course L0446: Digital Signal Proce	essing and Digital Filters
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Gerhard Bauch
Language Cycle	
Content	Transforms of discrete-time signals:
	• Discrete-time Fourier Transform (DTFT)
	 Discrete Fourier-Transform (DFT), Fast Fourier Transform (FFT) Z-Transform
	Correspondence of continuous-time and discrete-time signals, sampling, sampling theorem
	Fast convolution, Overlap-Add-Method, Overlap-Save-Method
	Fundamental structures and basic types of digital filters
	Characterization of digital filters using pole-zero plots, important properties of digital filters
	Quantization effects
	Design of linear-phase filters
	Fundamentals of stochastic signal processing and adaptive filters
	MMSE criterion
	• Wiener Filter
	• LMS- and RLS-algorithm
	Traditional and parametric methods of spectrum estimation
Literature	KD. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner.
	V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V.
	W. Hess: Digitale Filter. Teubner.
	Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall.
	S. Haykin: Adaptive fiter theory.
	L. B. Jackson: Digital filters and signal processing. Kluwer.
	T.W. Parks, C.S. Burrus: Digital filter design. Wiley.

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



Courses				
Title		Тур	Hrs/wk	CP
Advanced Topics in Control (L0661)			2	3
Advanced Topics in Control (L0662)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	Optimal and Robust Control			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matr	x inequalities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	wing learning results		
Professional Competence				
Knowledge	 Students can explain the advantages and shortcoming They can explain the representation of nonlinear syste They can explain how stability and performance condi They can explain how gridding techniques can be use They are familiar with polytopic and LFT representation of these model structures Students can explain how graph theoretic concepts ar They can explain the convergence properties of first of 	ms in the form of quasi-LPV systems tions for LPV systems can be formulated d to solve analysis and synthesis probler ns of LPV systems and some of the basic e used to represent the communication to	as LMI conditions ns for LPV systems c synthesis techniqu	
	 They can explain analysis and synthesis conditions fo Students can explain the state space representation actuator/sensor array They can explain (in outline) the extension of the boun for distributed controllers 	formation control loops involving either l	tems that are discr	etized according to
Skills	Skills • Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity design of controllers; they can do this using polytopic, LFT or general LPV models • They are able to use standard software tools (Matlab robust control toolbox) for these tasks • Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, usi provided			
Personal Competence Social Competence Autonomy	e Students can work in small groups and arrive at joint results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
		loctive Compulsory		
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: E			
Curricula	Electrical Engineering: Specialisation Control and Power Sys Electrical Engineering: Specialisation Control and Power Sys Aircraft Systems Engineering: Specialisation Aircraft Systems Computational Science and Engineering: Specialisation Syst International Management and Engineering: Specialisation II. Mechatronics: Specialisation System Design: Elective Compu Mechatronics: Specialisation Intelligent Systems and Robotic Biomedical Engineering: Specialisation Implants and Endopre Biomedical Engineering: Specialisation Artificial Organs and Biomedical Engineering: Specialisation Management and Bu	ems: Elective Compulsory Elective Compulsory ems Engineering and Robotics: Elective (Mechatronics: Elective Compulsory Isory s: Elective Compulsory estheses: Elective Compulsory Regenerative Medicine: Elective Compulso siness Administration: Elective Compulso	sory Iry	
	Biomedical Engineering: Specialisation Medical Technology Theoretical Mechanical Engineering: Core qualification: Elect Theoretical Mechanical Engineering: Technical Complementa	ive Compulsory		



Course L0661: Advanced Topics in	n 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	WiSe
Content	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Control of Spatially Interconnected Systems
	- Multidimensional signals, I2 and L2 signal norm
	- Multidimensional systems in Roesser state space form
	- Extension of real-bounded lemma to spatially interconnected systems
	- LMI-based synthesis of distributed controllers
	- Spatial LPV control of spatially varying systems
	- Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	
	Werner, H., Lecture Notes "Advanced Topics in Control"
	Selection of relevant research papers made available as pdf documents via StudIP

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



Nodule M1173: Applied S				
Courses				
Title		Тур	Hrs/wk	CP
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Problem-based Learning	2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain the statistical methods and the conditions of their use.			
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results			
Personal Competence				
Social Competence	e 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 Lect	ture 70		
Credit points				
	Written exam			
Examination duration and scale				
	Mechanical Engineering and Management: Spec	cialisation Management: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele			
Surreula	Mechatronics: Specialisation Intelligent Systems			
	Biomedical Engineering: Core qualification: Corr			
	Product Development, Materials and Production:			
		tion Bio- and Medical Technology: Elective Compulso	ry .	
	Theoretical Mechanical Engineering: Specialisat		' y	

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	
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 Statistics	
Тур	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	CP
Flexible Multibody Systems (L1632)		Lecture	2	3
Optimization of dynamical systems (L16		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	Mathematics I, II, III			
Knowledge	Mechanics I, II, III, IV			
	 Simulation of dynamical Systems 			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students demonstrate basic knowledge and underst	anding of modeling, simulation and analy	sis of complex rigid and fle	xible multibody syste
	and methods for optimizing dynamic systems after su	ccessful completion of the module.		
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze and	optimize basic problems of the dynamics	of rigid and flexible multibo	dy systems
			•	
	+ to describe dynamics problems mathematically			
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to do	ocument the corresponding results.		
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises.			
	+ acquaint themselves with the necessary knowledge	e to solve research oriented tasks.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
	Energy Systems: Core qualification: Elective Comput	sory		
Curricula	Aircraft Systems Engineering: Specialisation Aircraft			
	Mechatronics: Specialisation System Design: Elective			
	Mechatronics: Specialisation Intelligent Systems and			
	Product Development, Materials and Production: Con	e qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification	on: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory		



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

Course L1633: Optimization of dyn	ourse 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	Robert Seifried, Dr. Alexander Held			
Language	DE			
Cycle	WiSe			
Content	 Formulation and classification of optimization problems Scalar Optimization Sensitivity Analysis Unconstrained Parameter Optimization Constrained Parameter Optimization Stochastic optimization Stochastic optimization Industry optimization Topology Optimization 			
Literature	Bestle, D.: Analyse und Optimierung von Mehrkörpersystemen. Springer, Berlin, 1994. Nocedal, J., Wright, S.J.: Numerical Optimization. New York: Springer, 2006.			



Module M1229: Control La	ab B				
Courses					
Title		Тур	Hrs/wk	CP	
Control Lab V (L1667)		Laboratory Course	1	1	
Control Lab VI (L1668)		Laboratory Course	1	1	
Module Responsible	Prof. Herbert Werner				
Admission Requirements					
Recommended Previous					
Knowledge	State space methods				
	LQG control				
	H2 and H-infinity optimal control				
	uncertain plant models and robust c	ontrol			
	LPV control				
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge	Students can explain the difference	between validation of a control lop in simulation and exp	perimental validation		
Skills					
	Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model that				
	can be used for controller synthesis				
		apable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers			
	• They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implementation				
	of H-infinity optimal controllers				
	They are capable of representing model uncertainty, and of designing and implementing a robust controller				
	 They are capable of using standard scheduled controllers 	i software tools (Matlab Robust Control Toolbox) for the	e design and the imple	ementation of LPV ga	
Personal Competence					
Social Competence	 Students can work in teams to conduct 	uct experiments and document the results			
Autonomy	Students can independently carry or	ut simulation studies to design and validate control loops	3		
Workload in Hours	Independent Study Time 32, Study Time in	Lecture 28			
Credit points	2				
Examination	Colloquium				
Examination duration and scale					
Assignment for the Following		ol and Power Systems: Elective Compulsory			
Curricula	Mechatronics: Specialisation Intelligent Sys				
	Mechatronics: Specialisation System Desig				
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compulsory			

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

Course L1668: Control Lab VI	
Тур	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Antonio Mendez Gonzalez
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides



Courses					
itle			Тур	Hrs/wk	СР
dvanced Topics in Control (L1803)			Seminar	2	2
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous Knowledge	 Introduction to co Control theory a optimal and robu 	nd design			
Educational Objectives	After taking part success	fully, students have reach	ed the following learning results		
Professional Competence					
Knowledge	 Students can ex 	blain modern control. apply basic control conce	epts for different tasks		
Skills	Students acquireStudents general	-	ed aspects of modern control, based on spe d present them to the participants esentation	cified literature	
Personal Competence Social Competence	Students are capThey are able to	able of developing solutic provide appropriate feedb	ons and present them back and handle constructive criticism of th	eir own results	
Autonomy	 Students evalua 	rize themselves with a se	acks of different forms of presentation for sp cientific field, are able of introduce it and		
Workload in Hours	Independent Study Time	e 32, Study Time in Lecture	e 28		
Credit points	2				
Examination	Presentation				
Examination duration and scale	90 min				
Assignment for the Following Curricula	Mechatronics: Specialis	ation System Design: Elec	Power Systems: Elective Compulsory ctive Compulsory and Robotics: Elective Compulsory		

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

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Specialization System Design

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

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

Module M0752: Nonlinear	Dynamics			
Courses				
Title		Тур	Hrs/wk	CP
Nonlinear Dynamics (L0702)		Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the following	g learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts in Nonlin	ear Dynamics and to develop a	and research new terms and	l concepts.
Skills	Students are able to apply existing methods and procesures of N	onlinear Dynamics and to deve	lop novel methods and proc	cedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually	and to identify and follow up nov	vel research tasks by thems	elves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Aircraft Systems: El	ective Compulsory		
Curricula	Computational Science and Engineering: Specialisation Scientif	c Computing: Elective Compuls	sory	
	International Management and Engineering: Specialisation II. Me	echatronics: Elective Compulsor	ŷ	
	Mechanical Engineering and Management: Specialisation Mech			
	Mechatronics: Specialisation System Design: Elective Compulso			
	Mechatronics: Specialisation Intelligent Systems and Robotics: E			
	Biomedical Engineering: Specialisation Artificial Organs and Re		ompulsory	
	Biomedical Engineering: Specialisation Implants and Endoprost			
	Biomedical Engineering: Specialisation Medical Technology and			
	Biomedical Engineering: Specialisation Management and Busin		npulsory	
	Product Development, Materials and Production: Core qualificati			
	Theoretical Mechanical Engineering: Core qualification: Elective			
	Theoretical Mechanical Engineering: Technical Complementary	Course. Elective Compulsory		

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



Module M0803: Embedde				
Courses				
Title		Тур	Hrs/wk	CP
Embedded Systems (L0805)		Lecture	3	4
Embedded Systems (L0806)		Recitation Section (small)	1	2
Module Responsible	Prof. Heiko Falk			
Admission Requirements	None			
Recommended Previous	Computer Engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the for	llowing learning results		
Professional Competence				
Knowledge	Embedded systems can be defined as information process	ing systems embedded into enclosing prod	ducts. This course tea	ches the foundation
	such systems. In particular, it deals with an introduction ir	nto these systems (notions, common chara	acteristics) and their s	specification langua
	(models of computation, hierarchical automata, specificatio	n of distributed systems, task graphs, speci	fication of real-time a	pplications, translation
	between different models).			
	Another part covers the hardware of embedded systems: Sonsors, A/D and D/A converters, real-time capable communication hardw embedded processors, memories, energy dissipation, reconfigurable logic and actuators. The course also features an introduction into real- operating systems, middleware and real-time scheduling. Finally, the implementation of embedded systems using hardware/software co-des (hardware/software partitioning, high-level transformations of specifications, energy-efficient realizations, compilers for embedded processors)			
	covered.			
Skills	After having attended the course, students shall be able to	p realize simple embedded systems. The	students shall realize	which relevant part
	technological competences to use in order to obtain a func			
	of computations and feasible techniques for system-level of		•	•
	risks exist.			i bystern debign spe
Personal Competence				
Social Competence	Students are able to solve similar problems alone or in a gr	oup and to procept the results accordingly		
Social Competence	Students are able to solve similar problems alone of in a gr	oup and to present the results accordingly.		
Autonomy	Students are able to acquire new knowledge from specific I	iterature and to associate this knowledge v	vith other classes.	
Westlesdistless	la den en deut Otradu Time 404. Otradu Time in La struct 50			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points Examination	6 Written exam			
Examination duration and scale	90 minutes, contents of course and labs			
Assignment for the Following		arl: Specialization Computer Science: Elec	ivo Compulson	
Assignment for the Pollowing Curricula	General Engineering Science (German program, 7 semester	, , , , , , , , , , , , , , , , , , , ,		
Curricula				
	Electrical Engineering: Core qualification: Elective Compute		ue Compulstory	
	General Engineering Science (English program, 7 semeste	, ,	ive Compulsory	
	Computational Science and Engineering: Core qualification			
	Mechatronics: Specialisation System Design: Elective Com			
	Mechatronics: Specialisation Intelligent Systems and Robo	tics: Elective Compulsory		

Course L0805: Embedded System	IS		
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 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. 2nd Edition, Springer, 2012., Springer, 2012. 		



Course L0806: Embedded System	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	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		



Module M0805: Technical	Acoustics I (Acoustic Waves, Noise Prot	ection, Psycho Acoustics)				
Courses						
Title		Тур	Hrs/wk	СР		
Technical Acoustics I (Acoustic Waves	Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3		
Technical Acoustics I (Acoustic Waves	Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3		
Module Responsible	Prof. Otto von Estorff					
Admission Requirements	none					
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mecha	anics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge	Mathematics I, II, III (in particular differential equations)					
Educational Objectives	After taking part successfully, students have reached the	following learning results				
Professional Competence						
Knowledge	The students possess an in-depth knowledge in acoust	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give				
	an overview of the corresponding theoretical and methodical basis.					
Chille	s The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies an					
Skills	measurement procedures treated within the module.	blems in acoustics by theory-based appli	cation of the demand	ing metrodologies a		
	measurement procedures treated within the module.					
Personal Competence						
Social Competence						
Autonomy	The students are able to independently solve challengi	ng acoustical problems in the areas treated	within the module. Po	ossible conflicting issu		
	and limitations can be identified and the results are critic	cally scrutinized.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56					
Credit points	6					
Examination	Oral exam					
Examination duration and scale	20-30 Minuten					
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsor	у				
Curricula	Aircraft Systems Engineering: Specialisation Cabin Syst	ems: Elective Compulsory				
	International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory					
	Mechatronics: Specialisation System Design: Elective Compulsory					
	Product Development, Materials and Production: Core of	ualification: Elective Compulsory				
	Technomathematics: Core qualification: Elective Compu	Ilsory				
	Technomathematics: Specialisation III. Engineering Scie	ence: Elective Compulsory				
	Theoretical Mechanical Engineering: Specialisation Pro	duct Development and Production: Elective	Compulsory			
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory				

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



Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics

Course L0518: Technical Acoustic	ourse 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. Otto von Estorff	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses				
Title		Тур	Hrs/wk	CP
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, 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	he following learning results		
Professional Competence	· ····································			
Knowledge	The students possess an in-depth knowledge regard	ing the derivation of the boundary element me	thod and are able to	give an overview of
, nomedge	theoretical and methodical basis of the method.	ing the derivation of the boundary clement me		give an overview of
Skills	The students are capable to handle engineering pro	oblems by formulating suitable boundary elen	ents assembling th	e corresponding syst
on the	matrices, and solving the resulting system of equation		iento, assembling a	e conceptioning eyer
	matices, and solving the resulting system of equation	5.		
Personal Competence				
Social Competence	-			
Autonomy	The students are able to independently solve challeng	ning computational problems and develop own	boundary element r	utines Problems can
Autonomy	identified and the results are critically scrutinized.	and computational problems and develop own	boundary element it	dunies. I toblems can
	identified and the results are childany scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	Civil Engineering: Specialisation Structural Engineering	ng: Elective Compulsory		
Curricula	Civil Engineering: Specialisation Geotechnical Engine			
	Civil Engineering: Specialisation Coastal Engineering			
	Energy Systems: Core qualification: Elective Compuls			
	Computational Science and Engineering: Specialisati	•		
	Mechanical Engineering and Management: Specialisa		ctive Compulsorv	
	Mechatronics: Specialisation System Design: Elective	1		
	Product Development, Materials and Production: Core			
	Technomathematics: Specialisation III. Engineering So			
	Technomathematics: Core qualification: Elective Com			
	Theoretical Mechanical Engineering: Core qualification Theoretical Mechanical Engineering: Technical Comp			



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 Element	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		



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Courses				
Title		Тур	Hrs/wk	CP
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	Control Systems Theory and Design			
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 follo	wing learning results		
Professional Competence				
Knowledge				
0	Students can explain the significance of the matrix Ri		ms.	
	They can explain the duality between optimal state fe			
	They can explain how the H2 and H-infinity norms are			
	They can explain how an LQG design problem can be			
	 They can explain how model uncertainty can be repr They can explain how - based on the small gain the 		•	manaa far an unaar
	 mey can explain now - based on the small gain the plant. 		stability and perior	mance for an uncer
	 They understand how analysis and synthesis condition 	uns on feedback loops can be represented	as linear matrix ine	nualities
			as intear matrix met	duanties.
Skills	Students are capable of designing and tuning LOG or	patrolloro for multivoriable plant modele		
	 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 too 			
	for solving it.		i piant, and of using	Standard Soltware it
	 They are capable of translating time and frequency 	domain specifications for control loops	into constraints on	closed-loop sensit
	functions, and of carrying out a mixed-sensitivity design			
	 They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. 			
	 They are capable of formulating analysis and synthesis 			
	solving them.			
	They can carry out all of the above using standard so	tware tools (Matlab robust control toolbox).	
Personal Competence				
	Students can work in small groups on specific problems to an			
Autonomy	Students are able to find required information in sources p	rovided (lecture notes, literature, software	e documentation) ar	nd use it to solve gi
	problems.			
Wantilaadin Harris	Judana a da et Otado Tina d'Od. Otado Tina in La stara 50			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering:			
Curricula	Electrical Engineering: Specialisation Control and Power Sys	stems: Elective Compulsory		
	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory			
	Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elective Comp Mechatronics: Specialisation Intelligent Systems and Robotic	•		
	Biomedical Engineering: Specialisation Artificial Organs and		sorv	
	Biomedical Engineering: Specialisation Annotal Organs and Biomedical Engineering: Specialisation Implants and Endop	-	;	
	Biomedical Engineering: Specialisation Implants and Endop			
	Biomedical Engineering: Specialisation Medical rectinology Biomedical Engineering: Specialisation Management and Bu			
	Product Development, Materials and Production: Specialisat			
	Product Development, Materials and Production: Specialisat		-	
	Product Development, Materials and Production: Specialisat			
	Theoretical Mechanical Engineering: Core qualification: Elec			
	Theoretical Mechanical Engineering: Technical Complement			



Course L0658: Optimal and Robus	t 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 Robus	ourse L0659: Optimal and Robust Control	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Module M1143: Mechanica	al Design Methodology			
Module W1145. Mechanica	ai Design Methodology			
Courses				
Title		Тур	Hrs/wk	CP
Mechanical Design Methodology (L1523)	Lecture	3	4
Mechanical Design Methodology (L1524)	Recitation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	none			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	Science-based working on product design consid	ering targeted application of specific product desi	gn techniques	
Skills	s Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.			
Okiiis				
	design teerinques following theoretical aspects.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following	International Management and Engineering: Spec	ialisation II. Product Development and Production	n: Elective Compulsory	
Curricula	Mechatronics: Specialisation System Design: Elec	tive Compulsory		
	Biomedical Engineering: Specialisation Artificial C	Organs and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants a	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Manager	ent and Business Administration: Elective Comp	ulsory	
	Product Development, Materials and Production:		mpulsory	
	Product Development, Materials and Production:	Specialisation Production: Elective Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation		Compulsory	
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		

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



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



Courses					
Title		Тур	Hrs/wk	CP	
Automation and Simulation (L1525)		Lecture	3	3	
Automation and Simulation (L1527)		Recitation Section (large)	2	3	
Module Responsible	Prof. Günter Ackermann				
Admission Requirements	none				
Recommended Previous	BSc Mechanical Engineering or similar				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the for	ollowing learning results			
Professional Competence					
Knowledge	Students can describe the structure an the function of pro-	ocess computers, the corresponding compo	nents, the data tran	sfer via bus systems	
	programmable logic computers .				
	They can describe the basich principle of a numeric simula	ation and the corresponding parameters			
		ation and the corresponding parameters.			
	Thy can explain the usual method to simulate the dynamic	behaviour of three-phase machines.			
Skills	Students can describe and design simple controllers using	g established methodes.			
	They are able to access the basic characteristics of a given submation surfam and to evolute of it is a degree for a given plant.				
	They are able to assess the basic characterisitos of a given automation system and to evaluate, if it is adequate for a given plant. They can modell and simulate technical systems with respect to their dynamical behaviour and can use Matlab/Simulink for the sim They are able to applay established methods for the caclulation of the dynamical behaviour of three-phase machines.				
Personal Competence					
	Teamwork in small teams.				
Autonomy		ses in the field of automation systems to do t	nese analysisis in a	n adequate manner i	
, lotonomy	Students are able to identify the need of methocic analysises in the field of automation systems, to do these analysis in an adequate manner to evaluate the results critically.				
	·····,				
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points					
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Cabin System	ns: Elective Compulsory			
0002.0	Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory				
	International Management and Engineering: Specialisatio		Elective Compulsor	v	
	International Management and Engineering: Specialisatio				
	International Management and Engineering: Specialisatio	, , ,	lective Compulsory		
	Mechatronics: Specialisation System Design: Elective Cor		, ,		
	Mechatronics: Specialisation Intelligent Systems and Rob				
	Product Development, Materials and Production: Specialis		lsory		
	Product Development, Materials and Production: Specialis	sation Production: Elective Compulsory			
	Product Development, Materials and Production: Specialis				



Course L1525: Automation and Sir	mulation
Тур	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Günter Ackermann
Language	DE
Cycle	SoSe
Content	Structure of automation systsems
	Aufbau von Automationseinrichtungen
	Structure and function of process computers and corresponding componentes
	Data transfer via bus systems
	Programmable Logic Computers
	Methods to describe logic sequences
	Prionciples of the modelling and the simulation of continous technical systems
	Practical work with an established simulation program (Matlab/Simulink)
	Simulation of the dynamic behaviour of a three-phase maschine, simulation of a mixed continous/discrete system on base of tansistion flow diagrams.
Literature	U. Tietze, Ch. Schenk: Halbleiter-Schaltungstechnik; Springer Verlag
	R. Lauber, P. Göhner: Prozessautomatisierung 2, Springer Verlag
	Färber: Prozessrechentechnik (Grundlagen, Hardware, Echtzeitverhalten), Springer Verlag
	Einführung/Tutorial Matlab/Simulink - verschiedene Autoren

ourse L1527: Automation and Simulation		
Тур	Recitation Section (large)	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Günter Ackermann	
Language	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Module M1156: Systems I	Engineering			
Courses				
litle		Тур	Hrs/wk	CP
Systems Engineering (L1547)		Lecture	3	4
Systems Engineering (L1548)		Recitation Section (large)	1	2
Module Responsible	Prof. Ralf God			
Admission Requirements	None			
Recommended Previous	Basic knowledge in:			
Knowledge	Mathematics			
	Mechanics			
	Thermodynamics			
	Electrical Engineering			
	Control Systems			
	Previous knowledge in:			
	Aircraft Cabin Systems			
Educational Objectives	After taking part successfully, students have reached the t	following learning results		
Professional Competence				
Knowledge	Students are able to:			
	 understand systems engineering process models, method 	ods and tools for the development of comple	x Systems	
	 describe innovation processes and the need for technological 	ogy Management		
	explain the aircraft development process and the process	ss of type certification for aircraft		
	 explain the system development process, including requ 	uirements for systems reliability		
	 identify environmental conditions and test procedures for 	r airborne Equipment		
	value the methodology of requirements-based engineer	ing (RBE) and model-based requirements en	ngineering (MBRE)	
Skills	Students are able to:			
	• plan the process for the development of complex System	ns		
	• organize the development phases and development Tas	sks		
	• assign required business activities and technical Tasks			
	apply systems engineering methods and tools			
Personal Competence				
Social Competence	Students are able to:			
ecolar competence	understand their responsibilities within a development te	eam and integrate themselves with their role	in the overall process	
Autonomy	Students are able to:			
	interact and communicate in a development team which	has distributed tasks		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 Minutes			
Assignment for the Following	Aircraft Systems Engineering: Core qualification: Compute	sory		
Curricula	International Management and Engineering: Specialisation	on II. Aviation Systems: Elective Compulsory		
	International Management and Engineering: Specialisation	on II. Product Development and Production: I	Elective Compulsory	
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Mechatronics: Specialisation Intelligent Systems and Rob	ootics: Elective Compulsory		
	Product Development, Materials and Production: Speciali	sation Product Development: Compulsory		
	Product Development, Materials and Production: Speciali	sation Production: Elective Compulsory		
	Product Development, Materials and Production: Speciali	isation Materials: Elective Compulsory		





Course L1547: Systems Engineer	ing	
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	

Course 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



Module M1212: Technical	Complementary Course for IMPMEC (according to Subject Specific Regulations)
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Prof. Uwe Weltin
Admission Requirements	None
Recommended Previous	See selected module according to FSPO
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	see selected module according to FSPO
Skills	see selected module according to FSPO
Personal Competence	
Social Competence	see selected module according to FSPO
Autonomy	see selected module according to FSPO
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Examination	according to Subject Specific Regulations
Examination duration and scale	It. FSPO
• •	Mechatronics: Specialisation System Design: Elective Compulsory
Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory



Module M1223: Selected Topics of Mechatronics (Alternative A: 12 LP)

Courses Title				
Title				
		Тур	Hrs/wk	CP
Development Management for Mechatror	nics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Microcontroller Circuits: Implementation in Hardware and Software (L0087)		Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MBSE) with SysML/UML (L1551)		Problem-based Learning	3	3
Process Measurement Engineering (L10	77)	Lecture	2	3
Process Measurement Engineering (L108	83)	Recitation Section (large)	1	1
Feedback Control in Medical Technology	(L0664)	Lecture	2	3
Six Sigma (L1130)		Lecture	2	3
Reliability in Engineering Dynamics (L017	76)	Lecture	2	2
Reliability in Engineering Dynamics (L130	3)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics (A	Alternative A: 12 LP) or "Selected Topics o	f Mechatronics (Alte	rnative B: 6 LP)" c
-	selected.	,		,
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence		• •		
Knowledge				
Kilowieuge	 Students are able to express their extended knowl 	edge and discuss the connection of diffe	erent special fields	or application are
	mechatronics			
	 Students are gualified to connect different special fiel 	ds with each other		
Skills	 Students can apply specialized solution strategies an 	d new scientific methods in selected areas		
	 Students are able to transfer learned skills to new and 	a unknown problems and can develop owr	i solution approache	35
Personal Competence				
Social Competence				
Autonomy				
	Students are able to develop their knowledge and sk	lls by autonomous election of courses.		
Workload in Hours	Depends on choice of courses			
	12			
· · ·	Mechatronics: Specialisation System Design: Elective Comp	ulsory		



Course L1512: Development Mana	agement for Mechatronics		
Тур	ecture		
Hrs/wk	2		
CP			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale	30 Minuten		
Lecturer	Dr. Daniel Steffen		
Language	DE		
Cycle	SoSe		
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization 		
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morgen Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme 		

Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe/SoSe	
Content		
Literature		



Course L0724: Microsystems Tecl	hnology	
Тур	Lecture	
Hrs/wk		
	4	
	Independent Study Time 92, Study Time in Lecture 28	
Examination duration and scale	30 min	
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, molecular 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, comer undercuting, measures for compensation and etch-stop techniques; plasma processes, dry etching; back sputtering; plasma etching, RIE, Bosch process, cyp process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, provus silicon, SOI, SCREAM process, LIGA, SUB, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermopile; modulating sensors: accelerometer; piezoresistive, piezoresistive, angular rate sensor: perating principle and fabrication process; accelerometer; piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; accelerometer; piezoresistive, piezoelectric and eapacitive; magular rate sensor; clark electrode, enzyme electrode, DNA (hip) Mechanical Sensors (fibramal gas sensors: spellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, capanic resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, clambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principl	
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	
	a. donuon, m. 20120. Introduction to microsystem tournology, micy, 2000	



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



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

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



Course L0664: Feedback Control	in Medical Technology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	Taking an engineering point of view, the lecture is structured as follows.
	 Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart
	Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma		
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language		
Cycle	WiSe	
	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



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

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



Module M1224: Selected Topics of Mechatronics (Alternative B: 6 LP)

Courses				
Title		Тур	Hrs/wk	CP
Development Management for Mechatro	pnics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Microcontroller Circuits: Implementation	in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MB	SE) with SysML/UML (L1551)	Problem-based Learning	3	3
Process Measurement Engineering (L10	077)	Lecture	2	3
Process Measurement Engineering (L10	083)	Recitation Section (large)	1	1
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Six Sigma (L1130)		Lecture	2	3
Reliability in Engineering Dynamics (L01	76)	Lecture	2	2
Reliability in Engineering Dynamics (L13	03)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics of Mechatronics (Alternative B: 6 LP)" can be selected.			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge Skills	 Students are able to express their extended knowledge and discuss the connection of different special fields or application areas of mechatronics Students are qualified to connect different special fields with each other 			
	Students are able to transfer learned skills to new an	d unknown problems and can develop owr	solution approach	es
Personal Competence				
Social Competence				
Autonomy	Students are able to develop their knowledge and sk	ills by autonomous election of courses.		
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following	Mechatronics: Specialisation System Design: Elective Comp	ulsory		

Course L1512: Development Management for Mechatronics		
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 scale	30 Minuten	
Lecturer	Dr. Daniel Steffen	
Language	DE	
Cycle	SoSe	
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization 	
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morgen Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme 	



Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	



Course L0724: Microsystems Tec	hnology		
	Lecture		
Hrs/wk			
CP	4		
	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale			
Lecturer			
Language			
Cycle			
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVE 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: bac sputtering, plasma etching, RIE, Bosch process, rop process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origan microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive capacitive and fabrication process; accelerometer; piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle an fabrication process; (Harmal gas sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magnet resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle		
	 microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal corregeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysic FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip ch bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; mic 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	Problem-based Learning		
Hrs/wk	3		
CP	3		
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42		
Examination Form	Projektarbeit		
Examination duration and scale	ca. 10 Seiten		
Lecturer	Prof. Ralf God		
Language	DE		
Cycle	SoSe		
Content	Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning		
	about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a		
	realistic hardware platform (e.g. Arduino®, Raspberry Pi®):		
	What is a model?		
	What is Systems Engineering?		
	Survey of MBSE methodologies		
	The modelling languages SysML /UML		
	Tools for MBSE		
	Best practices for MBSE		
	Requirements specification, functional architecture, specification of a solution		
	From model to software code		
	Validation and verification: XiL methods		
	Accompanying MBSE project		
Literature	- Skript zur Vorlesung		
	- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008		
	- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011		



ourse L1077: Process Measurement Engineering		
Тур	ecture	
Hrs/wk		
CP		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche 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 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
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course



Course L0664: Feedback Control	in Medical Technology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	Taking an engineering point of view, the lecture is structured as follows.
	 Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart
	Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma		
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



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

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



Courses			
Title	Typ Hrs/wk CP		
Lab Cyber-Physical Systems (L1740)	Problem-based Learning 4 6		
Module Responsible	Prof. Heiko Falk		
Admission Requirements	None		
Recommended Previous	Module "Embedded Systems"		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Cyber-Physical Systems (CPS) are tightly integrated with their surrounding environment, via sensors, A/D and D/A converters, and actors. Due t their particular application areas, highly specialized sensors, processors and actors are common. Accordingly, there is a large variety of different specification approaches for CPS - in contrast to classical software engineering approaches.		
	Based on practical experiments using robot kits and computers, the basics of specification and modelling of CPS are taught. The lab introdu into the area (basic notions, characteristical properties) and their specification techniques (models of computation, hierarchical automata, data f models, petri nets, imperative approaches). Since CPS frequently perform control tasks, the lab's experiments will base on simple con applications. The experiments will use state-of-the-art industrial specification tools (MATLAB/Simulink, LabVIEW, NXC) in order to model cyte physical models that interact with the environment via sensors and actors.		
Skills	After successful attendance of the lab, students are able to develop simple CPS. They understand the interdependencies between a CPS and it surrounding processes which stem from the fact that a CPS interacts with the environment via sensors, A/D converters, digital processors, D/ converters and actors. The lab enables students to compare modelling approaches, to evaluate their advantages and limitations, and to decid which technique to use for a concrete task. They will be able to apply these techniques to practical problems. They obtain first experiences i hardware-related software development, in industry-relevant specification tools and in the area of simple control applications.		
Personal Competence			
Social Competence			
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Examination	Project		
Examination duration and scale	Execution and documentation of all lab experiments		
Assignment for the Following	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory		
Curricula			
	General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory		
	Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory		

Course L1740: Lab Cyber-Physical Systems		
Тур	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. 2nd Edition, Springer, 2012. Begleitende Foliensätze 	



Module M1306: Control La				
Courses				
Title		Тур	Hrs/wk	CP
Control Lab IX (L1836)		Laboratory Course	1	1
Control Lab VII (L1834)		Laboratory Course	1	1
Control Lab VIII (L1835)		Laboratory Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	State space methods			
	LQG control			
	 H2 and H-infinity optimal control 			
	 uncertain plant models and robust control 			
	LPV control			
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the difference between 	en validation of a control lop in simulation and exp	erimental validation	
Skills				
	 Students are capable of applying basic sy 	stem identification tools (Matlab System Identifica	tion Toolbox) to identi	fy a dynamic model t
	can be used for controller synthesis			
	 They are capable of using standard softward 	re tools (Matlab Control Toolbox) for the design an	d implementation of L	QG controllers
	They are capable of using standard softwa	re tools (Matlab Robust Control Toolbox) for the m	ixed-sensitivity design	and the implementati
	of H-infinity optimal controllers			
	 They are capable of representing model up 	ncertainty, and of designing and implementing a ro	bust controller	
		are tools (Matlab Robust Control Toolbox) for the		ementation of LPV ga
	scheduled controllers		0	0
Demonstration of the second se				
Personal Competence				
Social Competence	 Students can work in teams to conduct exp 	eriments and document the results		
Autonomy	Studente con independently correctut cim	lation studies to design and validate control loops		
	• Students can independently carry out sind	nation studies to design and validate control loops		
Workload in Hours	Independent Study Time 48, Study Time in Lecture	e 42		
Credit points	3			
Examination	Colloquium			
Examination duration and scale				
Assignment for the Following	Mechatronics: Specialisation Intelligent Systems a	and Robotics: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design: Elec	tivo Compulsory		

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

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



Module Manual M. Sc. "Mechatronics"

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



Courses				
litle		Тур	Hrs/wk	CP
Advanced Topics in Vibration (L1743)	I	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 co	ncepts of Advanced Vibrations and to develop and research new	terms and concepts.	
Skills	Students are able to apply existing methods and p	procesures of Advanced Vibrations and to develop novel methods	and procedures.	
Personal Competence				
Social Competence	Students can reach working results also in group	IS.		
Autonomy	Students are able to approach given research tas	sks individually and 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			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Computational Science and Engineering: Sp	pecialisation Scientific Computing: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design	n: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Syst	tems and Robotics: Elective Compulsory		
	Theoretical Mechanical Engineering: Core of	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compulsory		

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



Module M0835: Humanoid	Robotics			
Courses				
Title		Тур	Hrs/wk	CP
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	 Introduction to control systems 			
	Control theory and design			
	- Control alcory and design			
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid robots. 			
	 Students can explain numariou robots. Students learn to apply basic control conception 	ts for different tasks in humanoid robotics		
Skills	 Students acquire knowledge about selected 	appeate of humanoid rebation, based on appei	fied literature	
	 Students acquire knowledge about selected Students generalize developed results and p 		neu merature	
	 Students generalize developed results and p Students practice to prepare and give a pres 			
Personal Competence				
Social Competence	 Students are capable of developing solution 	a in interdisciplinery teams and present them		
		ck and handle constructive criticism of their ow	n roculte	
			in results	
Autonomy	 Otudente queluete eduentezza and dreubez 	to of different forms of presentation for an ecific	tool condicate the bas	teclution
	 Students evaluate advantages and drawbac Students femiliarize themselves with a solution 	entific field, are able of introduce it and follo		
	scientific discussion develops	entitic field, are able of introduce it and folio	w presentations of othe	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 2	28		
Credit points	2			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control and P	ower Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Systems and	d Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Election	ve Compulsory		
	Biomedical Engineering: Specialisation Artificial Org		npulsory	
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Medical Teo			
	Biomedical Engineering: Specialisation Manageme		oulsory	
	Theoretical Mechanical Engineering: Core qualifica			
	Theoretical Mechanical Engineering: Technical Cor	nplementary Course: Elective Compulsory		

Course L0663: Humanoid Robotic	\$
Тур	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
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).



Noulle Mooso. Linear and	Nonlinear System Identifikation			
Courses				
litle		Тур	Hrs/wk	CP
inear and Nonlinear System Identification	(L0660)	Lecture	2	3
Module Responsible				
Admission Requirements	Control Systems Theory and Design			
Recommended Previous				
Knowledge	Classical control (frequency response,	root locus)		
	State space methods			
	Discrete-time systems			
	 Linear algebra, singular value decomp 			
	Basic knowledge about stochastic proc	cesses		
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge			line din an an an air an an Article	
		nework of the prediction error method and its app	lication to a variety of line	ear and nonlinear mod
	structures			
		ptron networks are used to model nonlinear dynar		
		predictive control scheme can be based on neural		
	Ihey can explain the idea of subspace	e identification and its relation to Kalman realisation	n theory	
Skills				
		predicition error method to the experimental identifi	ication of linear and nonli	near models for dynan
	systems			
		onlinear predictive control scheme based on a neu		
		e algorithms to the experimental identification of lir		ystems
	They can do the above using standard	software tools (including the Matlab System Identi	fication Toolbox)	
Personal Competence				
Social Competence	Students can work in mixed groups on specific	c problems to arrive at joint solutions.		
Autonomy	Students are able to find required information	n in sources provided (lecture notes, literature, s	oftware documentation) a	nd use it to solve give
	problems.			
	ndependent Study Time 62, Study Time in Leo	cture 28		
Credit points				
	Dral exam 30 min			
	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory		
	Mechatronics: Specialisation Intelligent System			
	Mechatronics: Specialisation System Design: I		ompulson	
		ial Organs and Regenerative Medicine: Elective Co	ompuisory	
		nts and Endoprostheses: Elective Compulsory		
		cal Technology and Control Theory: Compulsory	mulaan	
		gement and Business Administration: Elective Con	npuisory	
	Fheoretical Mechanical Engineering: Core qua			
-	neoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsory		

Course L0660: Linear and Nonline	ar 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



Trie Typ Heavier CP Control Lab II (1193) Laboratory Course 1 1 Control Lab II (1193) Laboratory Course 1 1 Control Lab II (1193) Laboratory Course 1 1 Control Lab II (1193) Module Responsible Port Hartbert Weiner 1 1 Module Responsible Port Hartbert Weiner 1 1 1 Admission Requirements - - - - - Recommended Previous -	Module M0939: Control La	ab A			
Typ Hrawk CP Control Lab (L1050) Laboratory Course 1 1 Module Responsible Prof. Herbert Werner 1 1 Admission Requirements • • • • Recommended Previous Knowledge • State space methods • LOG control • uncertain plant models and robust control • uncertain plant models and robust control • LPV control • • Educational Objectives After taking part successfully, students have reached the following learning results • Professional Competence Knowledge • Students can explain the difference between validation of a control lop in simulation and experimental validation • Students are capable of applying basic system identification tools (Matlab System identification Toolbox) to identify a dynamic mod can be used for controller synthesis • • Students are capable of using standard software tools (Matlab Robust Control Toolbox) to ithe mixed sensitivity design and the implementand of Hotare of H-Infinity optimal controllers	Courses				
Samed Let (1950) Laboratory Course 1 1 Control Let (1,1950) Laboratory Course 1 1 Samed Let (1,1950) Laboratory Course 1 1 Control Let (1,1950) Interview Course 1 1 Samed Let (1,1950) Pol. Herbert Werner 1 1 Module Responsible Prol. Herbert Werner 1 1 Recommended Previous - State space methods - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - LGG control - Students can explain the difference between validation of a control lop in simulation and experimental validation - Students are capable of corapseting dodd control roolbox, for the design and the			Ture	Hane hude	CD
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Control Latio V(11666) Latiovatory Course 1 1 Control Lab V(11666) Prof. Herbert Werner Laboratory Course 1 1 Admission Requirements - - - - - Recommended Previous Knowledge - <				-	1
Central Lab V (1.166) Laboratory Cause 1 Module Response Prof. Hericet Werner Admission Requirements State space methods Concorded Previous After taking part successfully, students have reached the following learning results Perdessional Competence After taking part successfully, students have reached the following learning results Perdessional Competence Students can explain the difference between validation of a control lop in simulation and experimental validation Skills Students can explain the difference between validation totos (Matlab System Identification Toobox) to identify a dynamic mode can be used for controller synthesis Skills Students can explain the difference between validation ot a control lop in simulation and experimental validation Personal Competence Students can explain during standard software tools (Matlab Dotto) Toobox) for the design and implementation of LOG controllers They are capable of using standard software tools (Matlab Robust Control Toobox) for the design and the implementation of LPC Social Competence Students can independently carry out simulation studies to design and validate control loops Werkstaad in hop				-	1
Module Responsible Prof. Herbert Werner Admission Requirements • Recommended Previous Knowledge • State space methods LOG control H2 and H-Infinity optimal control U. Card control H2 and H-Infinity optimal control U. Card control LPV control Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge • Students are capable of applying basic system identification tools (Mattab System Identification Toolbox) to identify a dynamic mode can be used for controllers synthesis Skille • Students are capable of using standard software tools (Mattab Control Toolbox) for the design and implementation of LOG controllers They are capable of using standard software tools (Mattab Robust Control Toolbox) for the mixed-sensitivity design and the implement of H-Infinity optimal controllers Personal Competence Social				-	-
Admission Requirements • Recommended Previous Knowledge • State space methods • LQG control • H2 and H-Infinity optimal control • uncertain plant models and robust control • Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge • Skills • • • Skills • • • Skills • • • • • • • • • • • Skille		Prof. Herbert Werner			
Knowledge Sills space methods LOG control LOG control LPV control Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Subents can explain the difference between validation of a control lop in simulation and experimental validation Subents can explain the difference between validation of a control lop in simulation and experimental validation Subents can explain the difference between validation tools (Matlab System Identification Toolbox) to Identify a dynamic modic can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LOG controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers Sudents can work in teams to conduct experiments and document the results Sudents can independently carry out simulation studies to design and validate control loops Vorkload In Hom Advance Sudents can independently carry out simulation studies to design and validate control loops S		•			
Educational Objectives After taking part successfully, students have reached the following learning results Professional Competence Knowledge Knowledge • Students can explain the difference between validation of a control lop in simulation and experimental validation Skills • Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic modican be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and implementation of LPV scheduled controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • Students can independently carry out simulation studies to design and validate control loops Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Credit points Colloquium Examination duration and scale Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory </td <td></td> <td> LQG control H2 and H-infinity optimal control uncertain plant models and robust control </td> <td>ol</td> <td></td> <td></td>		 LQG control H2 and H-infinity optimal control uncertain plant models and robust control 	ol		
Professional Competence Knowledge Skills • Students can explain the difference between validation of a control lop in simulation and experimental validation Skills • Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic mode can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implement of H-infinity optimal controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • Students can work in teams to conduct experiments and document the results • Students can independently carry out simulation studies to design and validate control loops Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Credit points 4 Examination Colloquium Examination duration and scale Electrical Engineering: Specialisation Control and Power Systems: El		LPV control			
Knowlede • Students can explain the difference between validation of a control lop in simulation and experimental validation Skills • Students are capable of applying basic system identification tools (Matlab System identification Toolbox) to identify a dynamic mode can be used for controller synthesis • They are capable of using standard software tools (Matlab Control Toolbox) for the design and implementation of LQG controllers • They are capable of using standard software tools (Matlab Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers • Students can work in teams to conduct experiments and document the results Autonomy is Students can independently carry out simulation studies to design and validate control loops • Students can independent Study Time in Lecture 56 Credit pointa • Colloquium Exemination duration and scate • Students can system Design: Elective Compulsory Mechatonics: Specialisation System Design: Elective Compulsory • Mechatonics: Specialisation System and Powe		After taking part successfully, students have rea	ached the following learning results		
 Students are capable of applying basic system identification tools (Matlab System Identification Toolbox) to identify a dynamic model can be used for controller synthesis They are capable of using standard software tools (Matlab Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the mixed-sensitivity design and the implement of H-infinity optimal controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers They are capable of using standard software tools (Matlab Robust Control Toolbox) for the design and the implementation of LPV scheduled controllers Students can work in teams to conduct experiments and document the results Autonomy Students can independently carry out simulation studies to design and validate control loops Students can independently carry out simulation studies to design and validate control loops Students can independently carry out simulation studies to design and validate control loops Students can independently carry out simulation studies to design and validate control loops Students can independent study Time 64, Study Time in Lecture 56 Credit points Colloquium Ectrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory 		• Students can explain the difference betw	ween validation of a control lop in simulation and expe	erimental validation	
Social Competence Students can work in teams to conduct experiments and document the results Autonomy Students can independently carry out simulation studies to design and validate control loops Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Credit points Attaination duration and scale Examination duration and scale Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory	Skills	 can be used for controller synthesis They are capable of using standard soft They are capable of using standard soft of H-infinity optimal controllers They are capable of representing model They are capable of using standard so 	ware tools (Matlab Control Toolbox) for the design an ware tools (Matlab Robust Control Toolbox) for the mi I uncertainty, and of designing and implementing a ro	d implementation of Lo xed-sensitivity design bust controller	QG controllers and the implementati
Social Competence Students can work in teams to conduct experiments and document the results Autonomy Students can independently carry out simulation studies to design and validate control loops Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Credit points Examination Colloquium Examination duration and scale Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronical Engineering: Core qualification: Elective Compulsory	Personal Competence				
 Students can independently carry out simulation studies to design and validate control loops Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Credit points Colloquium Examination duration and scale Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Mechatronics: Specialisation Intelligent System and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory 	Social Competence	• Students can work in teams to conduct e	experiments and document the results		
Credit points 4 Examination Colloquium Examination duration and scale Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Mechatronics: Specialisation Intelligent System and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Autonomy	Students can independently carry out sin	mulation studies to design and validate control loops		
Examination Colloquium Examination duration and scale Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Curricula Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Workload in Hours	Independent Study Time 64, Study Time in Lect	ture 56		
Examination duration and scale Examination duration and scale Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Curricula Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Credit points	4			
Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Curricula Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Examination	Colloquium			
Curricula Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Examination duration and scale				
Curricula Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	Assignment for the Following	Electrical Engineering: Specialisation Control a	and Power Systems: Elective Compulsory		
Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory					
Theoretical Mechanical Engineering: Core qualification: Elective Compulsory					
i neoretical Mechanical Engineering: Lechnical Complementary Course: Elective Compulsory					
		i neoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory		

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



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

Course L1665: Control Lab III	urse L1665: Control Lab III	
Тур	Laboratory Course	
Hrs/wk	1	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Herbert Werner, Antonio Mendez Gonzalez	
Language	EN	
Cycle	WiSe/SoSe	
Content	One of the offered experiments in control theory.	
Literature	Experiment Guides	

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



Module M1223: Selected Topics of Mechatronics (Alternative A: 12 LP)

Courses				
Title		Тур	Hrs/wk	CP
Development Management for Mechatro	onics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Microcontroller Circuits: Implementation	in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MB	3SE) with SysML/UML (L1551)	Problem-based Learning	3	3
Process Measurement Engineering (L1)	077)	Lecture	2	3
Process Measurement Engineering (L1)	083)	Recitation Section (large)	1	1
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Six Sigma (L1130)		Lecture	2	3
Reliability in Engineering Dynamics (L01	76)	Lecture	2	2
Reliability in Engineering Dynamics (L13	303)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics (Alternative A: 12 LP) or "Selected Topics o	f Mechatronics (Alte	rnative B: 6 LP)" ca
	selected.			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following the students have reached the following the students have reached the students h	owing learning results		
Professional Competence				
Knowledge				
i ilionitage	Students are able to express their extended know	ledge and discuss the connection of diffe	rent special fields	or application area
	mechatronics			
	Students are qualified to connect different special field	lds with each other		
Skills	 Students can apply specialized solution strategies ar 	nd new scientific methods in selected areas		
	 Students are able to transfer learned skills to new an 			20
		d unknown problems and can develop own	solution apploach	55
Personal Competence				
Social Competence				
Autonomy				
	Students are able to develop their knowledge and sk	ills by autonomous election of courses.		
		ills by autonomous election of courses.		
		ills by autonomous election of courses.		
	 Students are able to develop their knowledge and sk 	ills by autonomous election of courses.		
Autonomy	Students are able to develop their knowledge and sk Depends on choice of courses	ills by autonomous election of courses.		
Autonomy Workload in Hours	Students are able to develop their knowledge and sk Depends on choice of courses 12			



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

Course L0310: Fatigue & Damage Tolerance		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	45 min	
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion	
Lecturer	Prof. Siegfried Rump	
Language	DE	
Cycle	WiSe/SoSe	
Content		
Literature		



Course L0724: Microsystems Tecl	hnology	
Тур		
Hrs/wk		
	Independent Study Time 92, Study Time in Lecture 28	
Examination duration and scale		
Lecturer	Prof. Hoc Khiem Trieu	
Language		
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, 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 undercuting, measures for compensation and etch-stop techniques; plasma processes, diverses, core 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 Raditation Sensors (thermopature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermopile; modulating sensors: scelectoric and capacitive; angular rate sensor: piezoresistive, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistiv; magnetoresistive sensors: integriting principle and fabrication process; accelerometer; piezoresistive, piezoelectric and capacitive; magular rate sensor: operating principle and fabrication process; accelerometer; piezoresistive, nerver electrode, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: splining current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas s	
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	
	A. Gondon, H. Bolzon introduction to microsystem technology, Hildy, 2000	



Тур	Problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Projektarbeit
Examination duration and scale	ca. 10 Seiten
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
	realistic hardware platform (e.g. Arduino®, Raspberry Pi®):
	What is a model?
	What is Systems Engineering?
	Survey of MBSE methodologies
	The modelling languages SysML /UML
	Tools for MBSE
	Best practices for MBSE
	Requirements specification, functional architecture, specification of a solution
	From model to software code
	Validation and verification: XiL methods
	Accompanying MBSE project
Literature	- Skript zur Vorlesung
	- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008
	- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011



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

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



Course L0664: Feedback Control	in Medical Technology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	Taking an engineering point of view, the lecture is structured as follows.
	 Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart
	Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma		
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



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

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



Module M1224: Selected Topics of Mechatronics (Alternative B: 6 LP)

Courses				
Title		Тур	Hrs/wk	СР
Development Management for Mechatro	onics (L1512)	Lecture	2	3
Fatigue & Damage Tolerance (L0310)		Lecture	2	3
Microcontroller Circuits: Implementation	in Hardware and Software (L0087)	Seminar	2	2
Microsystems Technology (L0724)		Lecture	2	4
Model-Based Systems Engineering (MB	SE) with SysML/UML (L1551)	Problem-based Learning	3	3
Process Measurement Engineering (L10	777)	Lecture	2	3
Process Measurement Engineering (L10	083)	Recitation Section (large)	1	1
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Six Sigma (L1130)		Lecture	2	3
Reliability in Engineering Dynamics (L01	76)	Lecture	2	2
Reliability in Engineering Dynamics (L13	03)	Recitation Section (small)	1	2
Module Responsible	Prof. Uwe Weltin			
Admission Requirements	Only one of the modules "Selected Topics of Mechatronics (selected.	Alternative A: 12 LP) or "Selected Topics o	f Mechatronics (Alte	rnative B: 6 LP)" can b
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	owing learning results		
Professional Competence				
Knowledge Skills	 Students are able to express their extended know mechatronics Students are qualified to connect different special fiel Students can apply specialized solution strategies are students and apply specialized solution strategies are students. 	ds with each other nd new scientific methods in selected areas		
	 Students are able to transfer learned skills to new an 	d unknown problems and can develop owr	solution approache	es
Personal Competence				
Social Competence				
Autonomy	Students are able to develop their knowledge and sk	ills by autonomous election of courses.		
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following	Mechatronics: Specialisation System Design: Elective Comp	ulsory		

Course L1512: Development Mana	agement for Mechatronics	
Тур	ecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	30 Minuten	
Lecturer	Dr. Daniel Steffen	
Language	DE	
Cycle	SoSe	
Content	 Processes and methods of product development - from idea to market launch identification of market and technology potentials development of a common product architecture Synchronized product development across all engineering disciplines product validation incl. customer view Steering and optimization of product development Design of processes for product development IT systems for product development Establishment of management standards Typical types of organization 	
Literature	 Bender: Embedded Systems - qualitätsorientierte Entwicklung Ehrlenspiel: Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit Gausemeier/Ebbesmeyer/Kallmeyer: Produktinnovation - Strategische Planung und Entwicklung der Produkte von morgen Haberfellner/de Weck/Fricke/Vössner: Systems Engineering: Grundlagen und Anwendung Lindemann: Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden Pahl/Beitz: Konstruktionslehre: Grundlagen erfolgreicher Produktentwicklung. Methoden und Anwendung VDI-Richtlinie 2206: Entwicklungsmethodik für mechatronische Systeme 	



Course L0310: Fatigue & Damage	Tolerance
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. 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 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 scale	10 min. Vortrag + anschließende Diskussion
Lecturer	Prof. Siegfried Rump
Language	DE
Cycle	WiSe/SoSe
Content	
Literature	



Course L0724: Microsystems Technology		
	Lecture	
Hrs/wk		
CP		
	Independent Study Time 92, Study Time in Lecture 28	
	Mündliche Prüfung	
Examination duration and scale		
Lecturer		
Language		
Cycle	WiSe	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner underculting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering; plasma etching, RIE, Bosch process, cryo process, XEP2 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: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; magular rate sensor: operating principle and fabrication process) Magnetic Sensors (fubrand gas sensors: splining current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, capanic semiconductor gas sensor, (Lawda and such fluxes), MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip)	
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	
	a. General, W. Bolzer, Introduction to histosystem technology, Wiley, 2000	



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



Course L1077: Process Measuren	nent 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 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 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
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Roland Harig
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course



Course L0664: Feedback Control i	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 scale	
Lecturer	Ulf Pilz, Prof. Olaf Simanski
Language	DE
Cycle	SoSe
Content	Taking an engineering point of view, the lecture is structured as follows.
	 Introduction to the topic with selected examples Physiology - introduction and overview Regeneration of functions of the cardiovascular system Regeneration of the respiratory functions Closed loop control in anesthesia regeneration of kidney and liver functions regeneration of motorize function/rehabilitation engineering navigation systems and robotic in medicine The lecture will use knowledge from modeling, simulation and controller design and MATLAB and SIMULINK will be used.
Literature	Silbernagel/Depopoulos: Taschenatlas der Physiologie, Thieme Verlag Stuttgart
	Werner: Kooperative und autonome Systeme der Medizintechnik, Oldenburg Verlag
	M.C.K.Khoo:"Physiological Control System", IEEE Press, 2000

Course L1130: Six Sigma		
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



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

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



Module M0603: Nonlinear	Structural Analysis			
Courses				
Title		Тур	Hrs/wk	CP
Nonlinear Structural Analysis (L0277)		Lecture	3	4
Nonlinear Structural Analysis (L0279)		Recitation Section (small)	1	2
Module Responsible	Prof. Alexander Düster			
Admission Requirements	None			
Recommended Previous	Mathematics I, II, III, Mechanics I, II, III, IV			
Knowledge	Differential Equations 2 (Partial Differential Equations)			
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	Students are able to			
-	+ give an overview of the different nonlinear phenomena in s	ructural mechanics.		
	+ explain the mechanical background of nonlinear phenomer			
	+ to specify problems of nonlinear structural analysis, to id	entify them in a given situation and to	explain their mather	matical and mechanica
	background.			
Skills	Students are able to			
	+ model nonlinear structural problems.			
	+ select for a given nonlinear structural problem a suitable co	mputational procedure.		
	+ apply finite element procedures for nonlinear structural ana	lysis.		
	+ critically verify and judge results of nonlinear finite elements	5.		
	+ to transfer their knowledge of nonlinear solution procedures	s to new problems.		
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to document	the corresponding results.		
	+ share new knowledge with group members.			
Autonomy	Students are able to			
hatohomy	+ assess their knowledge by means of exercises and E-Learn	ning.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following	Civil Engineering: Specialisation Structural Engineering: Elec	tive Compulsory		
Curricula	International Management and Engineering: Specialisation II		/	
	Materials Science: Specialisation Modeling: Elective Comput			
	Mechatronics: Specialisation System Design: Elective Comp			
	Product Development, Materials and Production: Core qualifi	•		
	Naval Architecture and Ocean Engineering: Core qualification			
	Ship and Offshore Technology: Core qualification: Elective C			
	Theoretical Mechanical Engineering: Core qualification: Elective of			
	Theoretical Mechanical Engineering: Core qualification: Liec Theoretical Mechanical Engineering: Technical Complement			
		ary course. Liective Computatiy		



Course L0277: Nonlinear Structural 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 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 M0746: Microsyst	em Engineering			
Courses				
Title		Тур	Hrs/wk	CP
Microsystem Engineering (L0680)		Lecture	2	4
Microsystem Engineering (L0682)		Problem-based Learning	1	1
Microsystem Engineering (L0681)		Recitation Section (small)	1	1
Module Responsible	Prof. Manfred Kasper			
Admission Requirements	None			
Recommended Previous	Basic courses in physics, mathematics and electric engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following I	earning results		
Professional Competence				
Knowledge	The students know about the most important technologies and mate	erials of MEMS as well as their app	lications in sensors a	nd actuators.
Skills	Students are able to analyze and describe the functional behaviour	r of MEMS components and to evalu	uate the potential of r	nicrosystems.
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group an	d to present the results accordingly		
Autonomy	Students are able to acquire particular knowledge using specialized	d literature and to integrate and ass	sociate this knowledg	e with other fields.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the Following	Electrical Engineering: Core qualification: Compulsory			
Curricula	Computational Science and Engineering: Specialisation Systems E	Engineering and Robotics: Elective	Compulsory	
	International Management and Engineering: Specialisation II. Elect	rical Engineering: Elective Compul	sory	
	International Management and Engineering: Specialisation II. Mech	natronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Mechatr	onics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and Regen	nerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthes	ses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and C	ontrol Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management and Business	s Administration: Elective Compulse	ory	
	Microelectronics and Microsystems: Core qualification: Elective Con	mpulsory		

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

Course L0682: Microsystem Engineering	
Тур	Problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Manfred Kasper
Language	EN
Cycle	WiSe
Content	Examples of MEMS components
	Layout consideration
	Electric, thermal and mechanical behaviour
	Design aspects
Literature	Wird in der Veranstaltung bekannt gegeben

Course L0681: Microsystem Engineering	
Тур	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Manfred Kasper
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Module M0806: Technical	Acoustics II (Room Acoustics, Comp	utational Methods)		
Courses				
Title		Тур	Hrs/wk	CP
Technical Acoustics II (Room Acoustics	, Computational Methods) (L0519)	Lecture	2	3
Technical Acoustics II (Room Acoustics	, Computational Methods) (L0521)	Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	none			
Recommended Previous	Technical Acoustics I (Acoustic Waves, Noise Protect	ction, Psycho Acoustics)		
Knowledge				
	Mechanics I (Statics, Mechanics of Materials) and M	echanics II (Hydrostatics, Kinematics, Dynamics)	
	Mathematics I, II, III (in particular differential equation	ns)		
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge in acoustics regarding room acoustics and computational methods and are able to give an overview			
	of the corresponding theoretical and methodical bas	sis.		
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding computational methods and procedures treated within the module.			
	procedures treated within the module.			
Personal Competence				
Social Competence				
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues			
	and limitations can be identified and the results are	critically scrutinized.		
	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	20-30 Minuten			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Cabin	Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design: Election	ve Compulsory		
	Product Development, Materials and Production: Co	ore qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Cor	nplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	Product Development and Production: Elective	Compulsory	

Course L0519: Technical Acoustics II (Room Acoustics, Computational 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	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)	
Litereture	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin	
Literature	Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg	
	Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg	
	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden	
	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin	



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



Module M0832: Advanced	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
	Prof. Herbert Werner		_	•
Admission Requirements	Optimal and Robust Control			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix	inequalities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge				
	 Students can explain the advantages and shortcomings 	of the classical gain scheduling approa	ich	
	 They can explain the representation of nonlinear system 	ns in the form of quasi-LPV systems		
	 They can explain how stability and performance condition 	ons for LPV systems can be formulated a	as LMI conditions	
	They can explain how gridding techniques can be used	to solve analysis and synthesis problem	ns for LPV systems	
	They are familiar with polytopic and LFT representation	s of LPV systems and some of the basic	synthesis technique	es associated with ea
	of these model structures		,	
	Students can explain how graph theoretic concepts are	used to represent the communication to	pology of multiagent	t systems
	 They can explain the convergence properties of first or 	der consensus protocols		
	They can explain analysis and synthesis conditions for	formation control loops involving either L	TI or LPV agent mo	dels
	 Students can explain the state space representation 	of spatially invariant distributed syst	ems that are discre	etized according to a
		of spatially invaliant distributed syst		suzed according to a
	actuator/sensor array			
	They can explain (in outline) the extension of the bound	ted real lemma to such distributed syste	ms and the associat	ed synthesis conditio
	for distributed controllers			
01:11-				
Skills	 Students are capable of constructing LPV models of 	of nonlinear plants and carry out a n	nixed-sensitivity des	sign of gain-schedule
	controllers; they can do this using polytopic, LFT or gen			0 0
	 They are able to use standard software tools (Matlab rol 			
	 Students are able to design distributed formation con 	trollers for groups of agents with eithe	r LTI or LPV dynam	nics, using Matlab too
	provided			
	 Students are able to design distributed controllers for sp 	atially interconnected systems using th		v
		alary interconnected systems, using th		^
Personal Competence				
Social Competence	Students can work in small groups and arrive at joint results.			
		vided (lecture peter literature cott	documentation)	d uso it to oche chi
Autonomy	Students are able to find required information in sources pro	vided (lecture notes, interature, software	- uocumentation) ar	iu use it to solve giv
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
· ·				
	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Ele	ective Compulsory		
Curricula	Electrical Engineering: Specialisation Control and Power Syste	ms: Elective Compulsory		
	Electrical Engineering: Specialisation Control and Power Syste			
	Aircraft Systems Engineering: Specialisation Aircraft Systems: B			
	Computational Science and Engineering: Specialisation System	• •	Compulsory	
	International Management and Engineering: Specialisation II. M	Aechatronics: Elective Compulsory		
		sorv		
	Mechatronics: Specialisation System Design: Elective Compuls			
	Mechatronics: Specialisation Intelligent Systems and Robotics:	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Biomedical Engineering: Specialisation Implants and Endopros	Elective Compulsory stheses: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Biomedical Engineering: Specialisation Implants and Endopros Biomedical Engineering: Specialisation Artificial Organs and R	Elective Compulsory stheses: Elective Compulsory egenerative Medicine: Elective Compuls		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Biomedical Engineering: Specialisation Implants and Endopros	Elective Compulsory stheses: Elective Compulsory egenerative Medicine: Elective Compuls		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Biomedical Engineering: Specialisation Implants and Endopros Biomedical Engineering: Specialisation Artificial Organs and R	Elective Compulsory stheses: Elective Compulsory egenerative Medicine: Elective Compulso ness Administration: Elective Compulso	ry	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Biomedical Engineering: Specialisation Implants and Endopros Biomedical Engineering: Specialisation Artificial Organs and R Biomedical Engineering: Specialisation Management and Busi	Elective Compulsory stheses: Elective Compulsory egenerative Medicine: Elective Compulso ness Administration: Elective Compulso nd Control Theory: Elective Compulsory	ry	



Course L0661: Advanced Topics in	n 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	WiSe
Content	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Control of Spatially Interconnected Systems
	- Multidimensional signals, I2 and L2 signal norm
	- Multidimensional systems in Roesser state space form
	- Extension of real-bounded lemma to spatially interconnected systems
	- LMI-based synthesis of distributed controllers
	- Spatial LPV control of spatially varying systems
	- Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	
	Werner, H., Lecture Notes "Advanced Topics in Control"
	Selection of relevant research papers made available as pdf documents via StudIP

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



Courses				
ïtle		Тур	Hrs/wk	СР
aboratory: Analog Circuit Design (L069	2)	Laboratory Course	2	3
aboratory: Digital Circuit Design (L0694)	Laboratory Course	2	3
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Basic knowledge of semiconductor devices an	d circuit design		
Knowledge				
Educational Objectives	After taking part successfully, students have read	ached the following learning results		
Professional Competence				
Knowledge				
		philosophy of the software framework for circuit design	1.	
	 Students can determine all necessary in Students know the basics physics of the 			
	 Students know the basics physics of the Students are able to explain the function 			
	 Students are able to explain the functio Students can explain the algorithms of a students can explain the algorithms of a students can explain the algorithms of a students can explain the students can e	ns of the logic gates of their digital design.		
		ate transistor models for fast and accurate simulations		
Skills				
	 Students can activate and execute all n 	ecessary checking routines for verification of proper ci	rcuit functionality.	
	 Students are able to run the input desks 			
	Students can define the specifications of			
	Students can optimize the electronic cir			
	Students can develop analog circuits for			
	Students can define the building blocks	or digital systems.		
Personal Competence				
Social Competence				
	 Students are trained to work through co 			
	 Students are able to share their knowle 			
		tand all the details and options of the design software.		
		egarding circuit design, so they do not go ahead, but th		en required.
	 Students can present their design approximation 	baches for easy checking by more experienced expert	S.	
A				
Autonomy		he status of their knowledge and to define actions for i		ecessary.
	Students can break down their design v	vork in sub-tasks and can schedule the design work in	a realistic way.	
	Students can handle the complex data	structures of their design task and document it in consi	ice but understandable	e way.
	Students are able to judge the amount	of work for a major design project.		
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	60 min			
		violization Information and Communication Technology	v Electivo Computere	,
Assignment for the Following	Mechatronics: Specialisation System Design: E	cialisation Information and Communication Technolog	y. ⊑lective Compuisory	r
Curricula	Microelectronics and Microsystems: Core quali			



ourse L0692: Laboratory: Analog Circuit Design	
Тур	Laboratory Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	 Input desk for circuits Algorithms for simulation MOS transistor model Simulation of analog circuits Placement and routing Generation of layouts Design checking routines Postlayout simulations
Literature	Handouts to be distributed

Course L0694: Laboratory: Digital	Circuit Design
Тур	Laboratory Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	SoSe
Content	 Definition of specifications Architecture studies Digital simulation flow Philosophy of standard cells Placement and routing of standard cells Layout generation Design checking routines
Literature	Handouts will be distributed



Courses				
		Ture	Hrs/wk	CP
Fitle ntegrated Product Development II (L12	54)	Typ Lecture	Hrs/wk 3	3
ntegrated Product Development II (L12)		Problem-based Learning	2	3
Module Responsible			_	-
Admission Requirements	None			
Recommended Previous	Basic knowledge of Integrated product develop	ment and applying CAF systems		
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	After passing the module students are able to:			
-				
	explain technical terms of design metho			
	describe essential elements of construct			
	 describe current problems and the current 	nt state of research of integrated product developme	nı.	
Skills	After passing the module students are able to:			
	 select and apply proper construction me 	thods for non-standardized solutions of problems as	well as adapt new bo	undary conditions
		th the assistance of a workshop based approach,	well as adapt new bot	indary conditions,
	 choose and execute appropriate moderation 			
Personal Competence				
Social Competence	After passing the module students are able to:			
	 prepare and lead team meetings and meetings 	oderation processes,		
	 work in teams on complex tasks, 	•		
	 represent problems and solutions and a 	dvance ideas.		
A				
Autonomy	After passing the module students are able to:			
	• give a structured feedback and accept a	critical feedback,		
	 implement the accepted feedback auton 	omous.		
Workload in Hours	Independent Study Time 110, Study Time in Le	ture 70		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 Minuten			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Ca	bin Systems: Elective Compulsory		
Curricula	Aircraft Systems Engineering: Specialisation Air			
	International Management and Engineering: Sp	ecialisation II. Product Development and Production	: Elective Compulsory	
	Mechatronics: Specialisation System Design: E		. ,	
		: Specialisation Product Development: Compulsory		
		: Specialisation Production: Elective Compulsory		
		: Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical			
	• •	ation Product Development and Production: Elective		



Course L1254: Integrated Product	Development II
Тур	Lecture
	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
	Prof. Dieter Krause
Language	DE
Cycle	
-	Lecture
	The lecture extends and enhances the learned content of the module "Integrated Product Development and lightweight design" and is based or the knowledge and skills acquired there.
	Topics of the course include in particular:
	Methods of product development,
	Presentation techniques,
	Industrial Design,
	Design for variety
	Modularization methods,
	Design catalogs,
	 Adapted QFD matrix, Systematic material selection,
	 Assembly oriented design,
	Construction management
	 CE mark, declaration of conformity including risk assessment, Patents, patent rights, patent monitoring Project management (cost, time, quality) and escalation principles, Development management for mechatronics,
	Technical Supply Chain Management. Exercise (PBL)
	In the exercise the content presented in the lecture "Integrated Product Development II" and methods of product development and desig management will be enhanced.
	Students learn an independently moderated and workshop based approach through industry related practice examples to solve complex an currently existing issues in product development. They will learn the ability to apply important methods of product development and desig 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 an management.
Literature	 Andreasen, M.M., Design for Assembly, Berlin, Springer 1985. Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007. Beckmann, H.: Supply Chain Management, Berlin, Springer 2004. Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinhein 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: Integrated Product	ourse L1255: Integrated Product Development II		
Тур	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		



Courses				
Title		Тур	Hrs/wk	CP
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Problem-based Learning	2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students can explain the statistical methods and the conditions of their use.			
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results			
Personal Competence				
Social Competence	Team Work, joined presentation of results			
Autonomy	To understand and interpret the question and solve			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes, 28 questions			
Assignment for the Following	Mechanical Engineering and Management: Special	sation Management: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design: Electiv	e Compulsory		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Biomedical Engineering: Core qualification: Compu	sory		
	Product Development, Materials and Production: Co	re qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Technical Cor	plementary Course: Elective Compulsory		

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 Statistics	
Тур	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	CP
Flexible Multibody Systems (L1632)		Lecture	2	3
Optimization of dynamical systems (L16		Lecture	2	3
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous	Mathematics I, II, III			
Knowledge	Mechanics I, II, III, IV			
	Simulation of dynamical Systems			
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge			sis of complex rigid and fle	xible multibody syste
	and methods for optimizing dynamic systems after suc	cessful completion of the module.		
Skills	Students are able			
	+ to think holistically			
	+ to independently, securly and critically analyze and	optimize basic problems of the dynamics of	of rigid and flexible multibo	dy systems
	+ to describe dynamics problems mathematically			
	+ to optimize dynamics problems			
Personal Competence				
Social Competence	Students are able to			
	+ solve problems in heterogeneous groups and to do	cument the corresponding results.		
Autonomy	Students are able to			
	+ assess their knowledge by means of exercises.			
	+ acquaint themselves with the necessary knowledge	to solve research oriented tasks.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Energy Systems: Core qualification: Elective Compuls	ory		
Curricula	Aircraft Systems Engineering: Specialisation Aircraft S	systems: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective	Compulsory		
	Mechatronics: Specialisation Intelligent Systems and	Robotics: Elective Compulsory		
	Product Development, Materials and Production: Core	equalification: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification	n: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comp	lementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comp	lementary Course: Elective Compulsory		



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

Course L1633: 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. Alexander Held	
Language	DE	
Cycle	WiSe	
Content	 Formulation and classification of optimization problems Scalar Optimization Sensitivity Analysis Unconstrained Parameter Optimization Constrained Parameter Optimization Stochastic optimization Stochastic optimization Industry 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				
litle		Тур	Hrs/wk	CP
inear and Nonlinear Waves (L1737)		Problem-based Learning	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	Master-Level			
Recommended Previous	Good Knowledge in Mathematics, Mechanics and Dynamics.			
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 in Wave Mechanics and to develop and research new terms and concepts.			
Skills	Students are able to apply existing methods and procesures of Wave Mechanics and to develop novel methods and procedures.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually	and 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			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Computational Science and Engineering: Specialisation	Scientific Computing: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Naval Architecture and Ocean Engineering: Core qualifi	cation: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Man	time Technology: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	nentary Course: Elective Compulsory		

Course L1737: Linear and Nonlinear Waves	
Тур	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.
Literature	G.B. Witham, Linear and Nonlinear Waves. Wiley 1999.
	C.C. Mei, Theory and Applications of Ocean Surface Waves. World Scientific 2004.

Module Manual M. Sc. "Mechatronics"



Module M1229: Control La	ab B			
Courses				
Title		Тур	Hrs/wk	CP
Control Lab V (L1667)		Laboratory Course	1	1
Control Lab VI (L1668)	1	Laboratory Course	1	1
Module Responsible	Prof. Herbert Werner			
Admission Requirements				
Recommended Previous				
Knowledge				
	LQG control			
	H2 and H-infinity optimal control			
	uncertain plant models and robust co	ontrol		
	LPV control			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	• Students can explain the difference h	between validation of a control lop in simulation and ex	perimental validation	
Skills		asic system identification tools (Matlab System Identific	ation Toolbox) to identi	ifv a dvnamic model t
	can be used for controller synthesis			,,
		software tools (Matlab Control Toolbox) for the design a	nd implementation of L	QG controllers
		software tools (Matlab Robust Control Toolbox) for the r		
	of H-infinity optimal controllers		, ,	
		odel uncertainty, and of designing and implementing a r	obust controller	
		I software tools (Matlab Robust Control Toolbox) for th		ementation of LPV ga
	scheduled controllers		0	0
Personal Competence				
Social Competence				
	Students can work in teams to condu	uct experiments and document the results		
Autonomy	Students can independently carry out	ut simulation studies to design and validate control loop	S	
Workload in Hours	Independent Study Time 32, Study Time in I	Lecture 28		
Credit points	2			
Examination	Colloquium			
Examination duration and scale				
Assignment for the Following	• • •	ol and Power Systems: Elective Compulsory		
Curricula	, ,			
	Mechatronics: Specialisation System Design	n: Elective Compulsory		
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compulsory		

Laboratory Course
1
1
Independent Study Time 16, Study Time in Lecture 14
Prof. Herbert Werner, Antonio Mendez Gonzalez
EN
WiSe/SoSe
One of the offered experiments in control theory.
Experiment Guides

Course L1668: Control Lab VI	
Тур	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Herbert Werner, Antonio Mendez Gonzalez
Language	EN
Cycle	WiSe/SoSe
Content	One of the offered experiments in control theory.
Literature	Experiment Guides



Courses				
ïtle		Тур	Hrs/wk	СР
dvanced Topics in Control (L1803)		Seminar	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Introduction to control systems 			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain modern control Students learn to apply basic control 			
Skills	Students acquire knowledge about set	elected aspects of modern control, based on specified is and present them to the participants a presentation	d literature	
Personal Competence Social Competence	Students are capable of developing s	olutions and present them feedback and handle constructive criticism of their ov	vn results	
Autonomy	 Students evaluate advantages and d 	awbacks of different forms of presentation for specific a scientific field, are able of introduce it and follo		
Workload in Hours	Independent Study Time 32, Study Time in L	ecture 28		
Credit points	2			
Examination	Presentation			
Examination duration and scale	90 min			
Assignment for the Following Curricula	• • •	: Elective Compulsory		
Course L1803: Advanced Topics	in Control			
ourse L1803: Advanced Topics	in Control			

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



Courses				
Title		Тур	Hrs/wk	CP
	and Electromagnetic Compatibility (L1669)	Lecture	3	4
	and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous	Basic principles of physics and electrical engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	Students can explain the basic principles, relationships, a	nd mothods for the design of waveguides	and antonnas as wo	Il as of Electromagne
Nilowiedge	Compatibility. Specific topics are:	na methods for the design of waveguides	and antennas as we	as of Electroniagne
	compatibility. Opcome topico are.			
	- Fundamental properties and phenomena of electrical circ	uits		
	- Steady-state sinusoidal analysis of electrical circuits			
	- Fundamental properties and phenomena of electromagne	etic fields and waves		
	- Steady-state sinusoidal description of electromagnetic fie	ds and waves		
	- Useful microwave network parameters			
	- Transmission lines and basic results from transmission lin	e theory		
	- Plane wave propagation, superposition, reflection and reflection	raction		
	- 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			
Skills	Students know how to apply various methods and models	for characterization and choice of waveg	uides and antennas 1	They are able to asse
	and qualify their basic electromagnetic properties. They			
	development of electrical components and systems.			
Personal Competence				
Social Competence	tence Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English		y in English (e.g. duri	
	small group exercises).			
Autonomy	Students are capable to gather information from subject re	lated professional publications and relate	that information to th	a context of the loctu
Autonomy	They are able to make a connection between their kr			
	electromagnetic fields, fundamentals of electrical engineer			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			Englight.
	6			
Credit points				
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following				
Curricula	Aircraft Systems Engineering: Specialisation Cabin System			
	Mechatronics: Specialisation System Design: Elective Con	ipulsory		



Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnet Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avion 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 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 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 - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)

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



Courses				
Title		Тур	Hrs/wk	СР
CMOS Nanoelectronics (L0764)		Lecture	2	3
CMOS Nanoelectronics (L1063)		Laboratory Course	2	2
CMOS Nanoelectronics (L1059)		Recitation Section (small)	1	1
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Fundamentals of MOS devices and electronic circuits			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge	Students can explain the functionality of very small	MOS transistors and explain the problems	occurring due to cos	ling down the minim
	feature size.	woo transistors and explain the problems		
	 Students are able to explain the basic steps of proce 	aning of yony amall MOS daviago		
	 Students are able to explain the basic steps of proce Students can exemplify the functionality of volatile a 		oifications	
	 Students can excribe the limitations of advanced M 		semeations.	
	 Students can describe the initiations of advanced w Students can explain measurement methods for MC 	·		
Skills	 Students can quantify the current-voltage-behavior 	of very small MOS transistors and list possib	le applications.	
	 Students can describe larger electronic systems by 			
	 Students can name the existing options for the spec 		riate ones.	
Personal Competence				
Social Competence				
Social Competence	Students can team up with one or several partners v	vho may have different professional backgr	ounds	
	Students are able to work by their own or in small gr	oups for solving problems and answer scie	ntific questions.	
Autonomy				
,	 Students are able to assess their knowledge in a rea 	alistic manner.		
	 The students are able to draw scenarios for estimati 	on of the impact of advanced mobile electro	onics on the future life	estyle of the society.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	Computational Science and Engineering: Specialisation Inf	ormation and Communication Technology:	Elective Compulsor	/
Curricula	International Management and Engineering: Specialisation	II. Electrical Engineering: Elective Compute	sory	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Com	pulsory		
	Microelectronics and Microsystems: Core qualification: Electronics	tive Compulsory		



Course L0764: CMOS Nanoelectro	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	 Ideal and non-ideal MOS devices Threshold voltage, Parasitic charges, Work function difference I-V behavior Scaling-down rules Details of very small MOS transistors Basic CMOS process flow Memory Technology, SRAM, DRAM, embedded DRAM Gain memory cells Non-volatile memories, Flash memory circuits Methods for Quality Control, C(V)-technique, Charge pumping, Uniform injection Systems with extremely small CMOS transistors
Literature	 S. Deleonibus, Electronic Device Architectures for the Nano-CMOS Era, Pan Stanford Publishing, 2009. Y. Taur and T.H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 2nd edition. R.F. Pierret, Advanced Semiconductor Fundamentals, Prentice Hall, 2003. F. Schwierz, H. Wong, J. J. Liou, Nanometer CMOS, Pan Stanford Publishing, 2010. HG. Wagemann und T. Schönauer, Silizium-Planartechnologie, Grundprozesse, Physik und Bauelemente Teubner-Verlag, 2003, ISBN 3519004674

Course L1063: CMOS Nanoelectro	ourse L1063: CMOS Nanoelectronics	
Тур	Laboratory Course	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	NN	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1059: CMOS Nanoelectronics	
Тур	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Thesis

	Module M-002: Master Thesis		
Courses			
Title	Typ Hrs/wk CP		
Module Responsible	Professoren der TUHH		
Admission Requirements			
	According to General Regulations §24 (1):		
	At least 78 credit points have to be achieved in study programme. The examinations board decides on exceptions.		
Recommended Previous			
Knowledge			
Educational Objectives			
Professional Competence Knowledge			
Thowledge	• 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 cur		
	developments and taking up a critical position on them.		
	• The students can place a research task in their subject area in its context and describe and critically assess the state of research.		
Skills	s 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 incomplet		
	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			
p			
	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 uphol		
	their own assessments and viewpoints convincingly.		
Autonomu	4 Students are able:		
Autonomy	/ Students are able:		
Autonomy	 Students are able: To structure a project of their own in work packages and to work them off accordingly. 		
Autonomy			
Autonomy	• To structure a project of their own in work packages and to work them off accordingly.		
	 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	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. Independent Study Time 900, Study Time in Lecture 0		
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	Theoretical Mechanical Engineering: Thesis: Compulsory
	Process Engineering: Thesis: Compulsory
	Water and Environmental Engineering: Thesis: Compulsory