

Module Manual

Master of Science (M.Sc.) Biomedical Engineering

Cohort: Winter Term 2020 Updated: 20th April 2023

Table of Contents

Table of Conte		2
Program descr		5
Core Qualificat		6
	Business & Management	6
	Non-technical Courses for Master Applied Statistics	7
		11
the second second second second second second		13
		15
		17
Module M1214:		19
Specialization	Implants and Endoprostheses	20
Module M0623:	Intelligent Systems in Medicine	20
		22
		29
		31
		33
		34
		36 38
		40
		42
		44
		47
Module M1151:	Material Modeling	49
		51
		52
		59
		60
		62
Module M1342:		64 66
		68 70
	······································	71
		73
		74
		76
		77
		79
		81
		83
		86
		88 89
		89 91
		92
		94
		95
	· · · · · · · · · · · · · · · · · · ·	96
Module M0548:		98
		00
Module M0623:		00
		02
		09
		11
		13
	Misses web was Task as low in Theory and Departies	14
	Control Systems Theory and Design	18
Module M0867		20
		22
		25
		27
Module M1199:	Advanced Functional Materials 1	29
Module M1241:		30
		37
		38
	Finite Elements Methods	40 42
Module M0808: Module M1342:		42
FIGURE FIESTER		

	Regenerative Medicine	146
Module M0630:	Robotics and Navigation in Medicine	148
Module M1384:	Case Studies for Regenerative Medicine and Tissue Engineering	150
Module M0634:	Introduction into Medical Technology and Systems	151
	Nonlinear Dynamics	153
	Semiconductor Technology	154
	Humanoid Robotics	156
	Linear and Nonlinear System Identifikation	157
	Optimal and Robust Control	159
	Marketing (Sales and Services / Innovation Marketing)	161
	Applied Design Methodology in Mechatronics	163
Module M0938:	Bioprocess Engineering - Fundamentals	165
Module M1277:	MED I: Introduction to Anatomy	168
Module M1280:	MED II: Introduction to Physiology	170
Module M1278:	MED I: Introduction to Radiology and Radiation Therapy	171
Module M1332	DIO I. Experimental Methods in Diameshanics	173
	BIO II: Experimental Methods in Biomechanics BIO II: Artificial Joint Replacement	174
	Foodback Control in Medical Technology	
	Feedback Control in Medical Technology	175
	Advanced Topics in Control	176
Module M0548:	Bioelectromagnetics: Principles and Applications	178
Specialization	Management and Business Administration	180
	Intelligent Systems in Medicine	180
	Selected Topics of Biomedical Engineering - Option A (6 LP)	182
Module M0620	Intelligent Autonomous Agents and Cognitive Robotics	189
	Microsystem Engineering	191
	Vibration Theory	193
	Finite Elements Methods	194
Module M0768:	Microsystems Technology in Theory and Practice	196
Module M0814:	Technology Management	198
Module M0846:	Control Systems Theory and Design	200
	Production Planning & Control and Digital Enterprise	202
	Flackwerk Classifie for Madical Applications	204
	Continuum Mechanics	207
	Material Modeling	209
Module M1199:	Advanced Functional Materials	211
Module M1241:	Selected Topics of Biomedical Engineering - Option B (12 LP)	212
	MED II: Introduction to Biochemistry and Molecular Biology	219
Module M1333:	BIO I: Implants and Fracture Healing	220
Module M1334:	BIO II: Biomaterials	222
Module M1342:	Polymers	224
	Regenerative Medicine	226
	Robotics and Navigation in Medicine	228
	Case Studies for Regenerative Medicine and Tissue Engineering	230
	Introduction into Medical Technology and Systems	231
	Nonlinear Dynamics	233
Module M0761:	Semiconductor Technology	234
Module M0835:	Humanoid Robotics	236
Module M0838:	Linear and Nonlinear System Identifikation	237
	Optimal and Robust Control	239
	Marketing (Sales and Services / Innovation Marketing)	241
	Discussion of Fundamental Construction of Cons	243
	Applied Design Methodology in Mechatronics	246
Module M1277:	MED I: Introduction to Anatomy	248
Module M1278:	MED I: Introduction to Radiology and Radiation Therapy	250
	MED II: Introduction to Physiology	252
Module M1332:	BIO I: Experimental Methods in Biomechanics	253
	BIO II: Artificial Joint Replacement	254
	Feedback Control in Medical Technology	255
	Advanced Tenics in Control	256
Modula M05/9	Bioelectromagnetics: Principles and Applications	258
	Medical Technology and Control Theory	260
Module M0623:	Intelligent Systems in Medicine	
	Selected Topics of Biomedical Engineering - Option A (6 LP)	262
	Intelligent Autonomous Agents and Cognitive Robotics	269
Module M0746:	Microsystem Engineering	271
	Vibration Theory	273
	Technology Management	274
	Microsystems Technology in Theory and Practice	276
	Control Systems Theory and Design	278
	Control Systems Theory and Design	
MOQUIE MO867:	Production Planning & Control and Digital Enterprise	280
	Electronic Circuits for Medical Applications	282
	Continuum Mechanics	285
	Material Modeling	287
Module M1199:	Advanced Functional Materials	289
Module M1241:	Selected Topics of Biomedical Engineering - Option B (12 LP)	290
		·

Module M1279: MED II: Introduction to Biochemistry and Molecular Biology	297
Module M1333: BIO I: Implants and Fracture Healing	298
Module M1334: BIO II: Biomaterials	300
Module M0808: Finite Elements Methods	302
Module M1342: Polymers	304
Module M0632: Regenerative Medicine	306
Module M0630: Robotics and Navigation in Medicine	308
Module M1384: Case Studies for Regenerative Medicine and Tissue Engineering	310
Module M0634: Introduction into Medical Technology and Systems	311
Module M0752: Nonlinear Dynamics	313
Module M0761: Semiconductor Technology	314
Module M0835: Humanoid Robotics	316
Module M0838: Linear and Nonlinear System Identifikation	317
Module M0840: Optimal and Robust Control	319
Module M0855: Marketing (Sales and Services / Innovation Marketing)	321
Module M1143: Applied Design Methodology in Mechatronics	323
Module M0938: Bioprocess Engineering - Fundamentals	
Module M1277: MED I: Introduction to Anatomy	328
Module M1280: MED II: Introduction to Physiology	330
Module M1278: MED I: Introduction to Radiology and Radiation Therapy	331
Module M1332: BIO I: Experimental Methods in Biomechanics	333
Module M1335: BIO II: Artificial Joint Replacement	334
Module M0845: Feedback Control in Medical Technology	335
Module M0635: Medical Technology Lab	336
Module M0832: Advanced Topics in Control	337
Module M0548: Bioelectromagnetics: Principles and Applications	339
Thesis	341
Module M-002: Master Thesis	341

Program description

Content

Graduates have acquired in-depth and extensive skills in engineering, mathematics and sciences that enable them to work scientifically in the field of medical technology, medical device technology and neighboring fields. They have a critical awareness of recent knowledge of their discipline, based on which they can act responsibly in their profession and society.

Career prospects

The demands on the health care continue to rise due to aging and the increased life expectations of the population. Here, the mechanization is of great importance. This applies to both individual implants and instruments as well as to large appliances used for diagnosis and therapy. Medical and engineering science personnel of the future will have to work more closely together to meet the new requirements. However, this also means that these fundamentally different disciplines must be able to understand the basics of problems of the "other" discipline. For engineers, this means that they understand and influence specific engineering basics and additionally medical and business aspects of patient care, project management, and development and research may need.

Learning target

The above mentioned qualifications are acquired by graduates during the course of their studies. The contents of the three areas are mapped to specializations: 'implants and prostheses "," Artificial Organs and Regenerative Medicine " can be management and administration "or" Medical and Control ".

Graduates are able to:

- analyze and solve scientific problems, even if they are defined in an uncommon way or incompletely and have competing specifications;
- Apply innovative methods in basic research problem solving and develop new scientific methods;
- identify information needs, find information and fundraising;
- theoretical and experimental investigation plan and perform;
- · Evaluate data critically and draw conclusions;
- analyze and evaluate the use of new and emerging technologies.
- Concepts and solutions to basic research, partly unusual issues possibly involving other disciplines to develop;
- to create new products, processes and methods;
- apply their scientific engineering judgment to work with complex, possibly incomplete information to identify contradictions and deal with them;
- classify knowledge from different fields methodically and combine systematically and handle complexity;
- · familiarize themselves systematically and in a short time with new tasks;
- To systematically reflect non-technical implications of engineering activity and responsibly integrate into their actions.

Core Qualification

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

Courses

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

Module Responsible	Dagmar Richter
Admission Requirements	
Recommended Previous	None
Knowledge	
-	After taking part successfully, students have reached the following learning results
Professional Competence Knowledae	The Nontechnical Academic Programms (NTA)
	imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fu Self-reliance, self-management, collaboration and professional and personnel management competences. The departme implements these training objectives in its teaching architecture , in its teaching and learning arrangements , in teach areas and by means of teaching offerings in which students can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechn complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechn academic programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual development competences. It also provides orientation knowledge in the form of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation study these subjects in one or two specific semesters during the course of studies.
	Teaching and Learning Arrangements
	provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dea with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberat encouraged in specific courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical stud communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the wir semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start- 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 georiented 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. Th differences are reflected in the practical examples used, in content topics that refer to different professional application conte and in the higher scientific and theoretical level of abstraction in the B.Sc.
	This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leaders functions of Bachelor's and Master's graduates in their future working life.
	Specialized Competence (Knowledge)
	Students can
	 explain specialized areas in context of the relevant non-technical disciplines, outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in learning area, different specialist disciplines relate to their own discipline and differentiate it as well as make connections, sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of represental in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, Can communicate in a foreign language in a manner appropriate to the subject.
Skills	Professional Competence (Skills)
	In selected sub-areas students can
	 apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned special 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

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.

	-					
ses						
			Тур		Hrs/wk	СР
ed Statistics (L1584)			Lecture		2	3
ed Statistics (L1586) ed Statistics (L1585)			, ,	oroblem-based Learning n Section (small)	2 1	2 1
	of Michael Marlack		Recitation	Section (smail)	Ţ	I
Module Responsible						
dmission Requirements N						
Recommended Previous B	sic knowledge of stat	istical methods				
Knowledge		<u> </u>				
Educational Objectives A	er taking part succes	sfully, students have r	reached the following learnin	ig results		
ofessional Competence						
5	Students can explain the statistical methods and the conditions of their use.					
	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results					
Personal Competence						
Social Competence T	Team Work, joined presentation of results					
Autonomy T	To understand and interpret the question and solve					
Workload in Hours In	lependent Study Time	e 110, Study Time in L	ecture 70			
Credit points 6						
course demeternene		Form	Description			
Y.		Written elaboration				
Examination W						
amination duration and 9	minutes, 28 question	IS				
scale	<u> </u>					
-	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory					
-	Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
		• •		mpulsory		
		: Core Qualification: Co				
			on: Core Qualification: Election			
		5 5	I Complementary Course: El	, ,		
		5 5	ation Bio- and Medical Techr	, ,	lsory	

Course L1584: Applied Statis	tics		
Тур	Lecture		
Hrs/wk			
СР	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 		
Literature	Determining critical sample sizes Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6		

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

Course L1585: Applied 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					
Fitle		Тур	Hrs/wk	СР	
Medical Imaging Systems (L0819)		Lecture	4	6	
Module Responsible	Dr. Michael Grass				
Admission Requirements	None				
Recommended Previous	none				
Knowledge					
Educational Objectives	After taking part successfully, students h	nave reached the following learning results			
Professional Competence					
Knowledge					
	Students can:				
	 Describe the system configuration 	n and components of the main clinical imagir	na systems:		
		nts and the overall system of the imaging sy			
		ocesses that make imaging possible and use		ysical equations;	
	 Name and describe the physical effects required to generate image contrasts; 				
	 Explain how spatial and temporal 	resolution can be influenced and how to cha	racterize the images gen	erated;	
	Explain which image reconstruction	on methods are used to generate images;			
	Describe and explain the main clinical u	ses of the different systems.			
Skills	/s Students are able to:				
	• Explain the physical processes of	images and assign to the systems the basic	mathematical or physical	equations require	
	 Calculate the parameters of 	f imaging systems using the mathematical o	or physical equations;		
	 Determine the influence of 	different system components on the spatial	and temporal resolution of	of imaging system	
	 Explain the importance of one of the second s	different imaging systems for a number of cli	inical applications;		
	Select a suitable imaging system for an	application.			
Personal Competence					
Social Competence	none				
Autonomy	Students can:				
	 Understand which physical offects 	are used in medical imaging			
	 Understand which physical effects Decide independently for which c 	linical issue a measuring system can be used	4		
		inited issue a measuring system can be used	4.		
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
•	Electrical Engineering: Specialisation Me				
Following Curricula	Biomedical Engineering: Core Qualificati		ti Electivo Compulsor		
	•	duction: Specialisation Product Development duction: Specialisation Production: Elective C			
		duction: Specialisation Production: Elective C duction: Specialisation Materials: Elective Co			
	•	chnical Complementary Course: Elective Com			
	Theoretical Mechanical Engineering: Spe				

Course L0819: Medical Imagi	ourse L0819: Medical Imaging Systems				
Тур	Lecture				
Hrs/wk					
СР	6				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Lecturer	Dr. Michael Grass, Dr. Sven Prevrhal, Dr. Tim Nielsen, Frank Michael Weber				
Language	DE				
Cycle	SoSe				
Content					
Literature	Primary book:				
	1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press				
	Secondary books:				
	- A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003.				
	- W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002.				
	- H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995.				
	- O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.				

Courses				
Title		Тур	Hrs/wk	СР
Medical Basics and Pathology I (L1	599)	Lecture	2	2
Medical Basics and Pathology II (L1	600)	Lecture	2	2
Medical Basics and Pathology III (L	1602)	Lecture	2	2
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in Le	cture 84		
Credit points	6			
Course achievement				
Examination	Written exam			
Examination duration and	120 minutes			
scale				
Assignment for the	International Management and Engineering: S	pecialisation II. Process Engineering and	Biotechnology: Elective	Compulsory

Course L1599: Medical Basic	s and Pathology I
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Julian Schulze zur Wiesch
Language	DE
Cycle	SoSe
Content	Upon successful completion of the course, participants should be able to describe the foundations of the organization of the German health system and to describe different ways of treatment in the hospital. They should be able to describe the anatomy, physiology and basic diagnostic possibilities for the following organ system: heart / circulatory system, lungs, digestive tract, kidney, including the technical possibilities of monitoring heart-lung function, in the emergency department, in the monitoring stations and in intensive care and the basics of cardiopulmonary resuscitation. Furthermore, the anatomy and physiology of the nervous system will be explored. The importance and possibilities of preventive medicine of serious public health problems are described. Students prepare their own sub-themes in the form of small lectures and discuss various clinical cases on these topics interactively as problem-based learning. This course/Lecture by excursions into our emergency room, our endoscopy unit, minilaparoscopy and our ICU as well as out patient clinics.
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1600: Medical Basic	s and Pathology II
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Johannes Kluwe
Language	DE
Cycle	WiSe
Content	Major diseases of
	 the gastrointestinal system and the liver, the hormone system, the kidneys. The lecture will focus on pathophysiology, symptoms, diagnostic and therapeutic principles of these diseases. I Gastrointestinal tract and liver: Gastrointestinal bleeding: causes, symptoms, endoscopic treatment options Colorectal cancer: basics, principle of prophylactic screening, therapy Liver diseases / liver cirrhosis: causes, symptoms, complications, therapeutic options II Hormones: Diabetes mellitus type 1 and 2: pathophysiology, complications, basics of glucose metabolism, therapeutic principles Thyreoid gland - hyper- and hypothyreoidism: causes, symptoms diagnostics, therapy III Kidneys Functions and failure, diagnostics, principles of renal replacement therapy
litoraturo	Wird in der Veranstaltung bekannt gegeben
Literature	wird in der Veranstaltung bekallfit gegeben

Course L1602: Medical Basic	s and Pathology III
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Dominic Wichmann
Language	DE
Cycle	WiSe
Content	a) Basic understanding of the pathology/pathophysiology of cardiac diseases and their stage-adapted treatments: coronary heart disease, myocardial infarction, mitral valve insufficiencies, aortic valve stenosis
	 b) Basic understanding of the pathology/pathophysiology of pulmonary diseases and their stage-adapted treatments: asthma, chronic obstructive pulmonary disease, pneumonia, bronchial cancer c) Basic understanding of infectious diseases, immune-system and autoimmune diseases
Literature	Skript zur Vorlesung.

Courses				
ïtle		Тур	Hrs/wk	СР
	ent, Materials and Production (L1566)	Practical Course	6	6
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous	Product Development:			
Knowledge	 Lectures: Mechanics I-III Lectures: Integrated Product Development Materials: Lectures: Structural Metallic Materials, Me 		ntroduction to Materi	als Testing
	 Lectures: Structure and Properties of Pol Composites Production: Lecture: Production Engineering Lectures: Forming and Cutting Technology Lectures: Machine Tools and Robotic 		nposites, Manufactur	ing of Polymers a
-	After taking part successfully, students have read	ched the following learning results		
Professional Competence	Students can			
	 represent more complex context of differe describe functionality of modern measure 		nologies.	
Skills	 Students are capable of applying theoretical knowledge for practic applying provided experimental methods analyzing and evaluating experimental res applying modern measurement instrument 	for examining contexts of different fields sults by using provided methods.	of study.	
Personal Competence Social Competence	Students con			
Social competence	 carry out and document experimental wor present and discuss experimental results i 	• •	1.	
Autonomy	Students are able to			
	 carry out parts of experimental work indep choose and apply suitable instruments. assess own strengths and weaknesses. 	Jendentry guided by teachers.		
	Independent Study Time 96, Study Time in Lectu	ire 84		
Credit points				
	None			
	Written elaboration			
Examination duration and scale				
	Biomedical Engineering: Core Qualification: Com	nulcon.		

Түр	Practical Course
Hrs/wk	
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Wolfgang Hintze, Prof. Bodo Fiedler, Prof. Claus Emmelmann, Prof. Dieter Krause, Prof. Gerold Schneider, Prof. Hermann
	Lödding, Prof. Jörg Weißmüller, Prof. Josef Schlattmann, Prof. Michael Morlock, Prof. Otto von Estorff, Prof. Thorsten Schüppstuhl,
	Prof. Uwe Weltin
Language	DE
Cycle	SoSe
Content	Product Development:
	Modal analysis - experimental and computational
	Appropriate design in engineering
	Characterization of rubbery-elastic materials
	Stick-Slip-Analysis at friction and wear test station
	Materials:
	Property profiles of steel
	Actuators for modern fuel injection systems - synthesis and properties
	 Processing, properties and structure of thermoplastic polymers and its composites
	Tribology in joints
	Production:
	Optimization of welding process parameters for hybrid plasma laser welding
	Evaluation of stock removal processes
	Analysis of basic laws in production logistics
	 Analysis of positioning behaviour and trajectory accuracy of industrial robots
Literature	Nach Themenstellung / depending on topic

Courses				
Title		Тур	Hrs/wk	СР
Casestudies Surgery and Internal M	ledicine (L1603)	Seminar	5	5
Clinical Internship (L1587)		Practical Course	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	The lectures addressing medical issue	s from the concentration Biomedical Engineering in	the respective BSc F	Programs.
Knowledge				
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
	The students learn the process of clinical practice regarding medical history, diagnosis and treatment decision with represent surgical and medical diseases in the various departments, and get an insight into the daily patient care through case studies hospital.			ugh case studies i
Skills	Interpreting and explaining the medical history and medical records of a patient. Dealing with patients.			
Personal Competence				
Social Competence	Dealing with patients.			
Autonomy				
Workload in Hours	Independent Study Time 96, Study Tin	ne in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	5 Pages (10 Case studies)			
scale				
Assignment for the	Biomedical Engineering: Core Qualifica	ation: Compulsory		
Following Curricula				

Course L1603: Casestudies S	urgery and Internal Medicine
Тур	Seminar
Hrs/wk	5
СР	
Workload in Hours	Independent Study Time 80, Study Time in Lecture 70
	Dr. Dominic Wichmann, Dr. Johannes Kluwe
Language	
Cycle	WiSe/SoSe
Content	Die Fallstudien werden in einem 2-wöchentlichen Blockkurs in der Innere und Chirurgie demonstriert. Alle 1-2 Tage wechseln die
	Stationen hierzu gehören:
	- Notaufnahme
	- Intensivstation
	- Pneumologie
	- Gastroenterologie
	- Kardiologie
	- Transfusionsmedizin
	- Poliklinik/Ambulanz
	- Dialyse
	- Unfallchirugie
Literature	keine spezifische

Course L1587: Clinical Interr	ıship
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe/SoSe
Content	The students complete a 1-week clinical internship in a hospital.
	The students organize the execution of the clinical internship in a hospital self-reliant. The choice of hospital has to be agreed with the program director.
Literature	keine

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Courses				
Title		Тур	Hrs/wk	СР
Module Responsible				
Admission Requirements				
	Subjects of the Master program and the specialisations.			
Knowledge				
	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	 Students can explain the project as well as their a of study. 	utonomously gained knowle	dge and relate it to curren	t issues of their fie
They can explain the basic scientific methods they have worked with.				
Skills	s The students are able to autonomously solve a limited scientific task under the guidance of an experienced researcher. They ca justify and explain their approach for problem solving; they can draw conclusions from their results, and then can find new way and methods for their work. Students are capable of comparing and assessing alternative approaches with their own with rega to given criteria.			
Personal Competence				
Social Competence	The students are able to condense the relevance and the for the presentation and discussion in front of a bigger their peers and supervisors.			
Autonomy	The students are capable of independently planning an deadlines. This includes the ability to accurately procur from experts with regard to the progress of the work, ar	e the newest scientific inform	nation. Furthermore, they	can obtain feedba
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0			
Credit points	12			
Course achievement	None			
Examination	Study work			
Examination duration and	according to FSPO			
scale				
Assignment for the	Biomedical Engineering: Core Qualification: Compulsory			
Following Curricula				

Specialization Implants and Endoprostheses

Module M0623: Intelli	igent Systems i	n Medicine				
Module Mod25. Intelli	igent Systems i	in Medicine				
Courses						
Title				Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331)				Lecture	2	3
Intelligent Systems in Medicine (L0334)Project Seminar22Intelligent Systems in Medicine (L0333)Recitation Section (small)11				2		
Module Responsible						
-	None					
Recommended Previous						
Knowledge		th (algebra, analysis/calc	culus)			
	 principles of sto 		DALLE			
	 principles of pro advanced progr 	ogramming, Java/C++ and	d R/Matiab			
Educational Objectives	After taking part succ	essfully, students have re	ached the followir	ng learning results		
Professional Competence						
Knowledge				anning and decision suppo		
				classification and their res		
		in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy				
	and safety requirement		licityes due to the			in and due to privacy
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess					
	the methods based or	actual patient data and	evaluate the imple	emented methods.		
Personal Competence						
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.					
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate					
hatohomy	manner.					
		ne 110, Study Time in Le	cture 70			
•	6 Compulsony Bonus	Form	Description			
Course achievement	Compulsory Bonus Yes 10 %	Written elaboration	Description			
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: Sp	ecialisation II: Intelligence	e Engineering: Ele	ctive Compulsory		
Following Curricula		Specialisation Medical Te				
		sation Intelligent System				
	-		•	enerative Medicine: Elective	Compulsory	
	-	• •		eses: Elective Compulsory Control Theory: Elective Cor	npulsory	
	÷	•		s Administration: Elective Co		
	-			ourse: Elective Compulsory		
				cal Technology: Elective Co		

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

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

Course L0333: Intelligent Sy	urse 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		

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	val of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Artificial Organ			

Course L1663: Nature's Hiera	archical Materials
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc.This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics:
	 Fundamental properties and phenomena of electrical circuits Steady-state sinusoidal analysis of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves Useful microwave network parameters Transmission lines and basic results from transmission line theory Plane wave propagation, superposition, reflection and refraction General theory of waveguides and their properties Radiation and basic antenna parameters Numerical techniques and CAD tools for waveguide and antenna design Fundamentals of Electromagnetic Compatibility Coupling mechanisms and countermeasures Shielding, grounding, filtering Standards and regulations 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	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1588: Development	and Regulatory Approval of Implants	
Тур	icture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Roman Nassutt	
Language	DE	
Cycle	WiSe	
Content		
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html 	

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics			
Тур	eminar		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	SoSe		
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 		
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009		

Course L1890: Seminar Biomedical Engineering		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

Course L1130: Six Sigma		
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	

Course L0001: Fluid Mechani	ics II
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	 Differential equations for momentum-, heat and mass transfer Examples for simplifications of the Navier-Stokes Equations Unsteady momentum transfer Free shear layer, turbulence and free jets Flow around particles - Solids Process Engineering Coupling of momentum and heat transfer - Thermal Process Engineering Rheology - Bioprocess Engineering Coupling of momentum- and mass transfer - Reactive mixing, Chemical Process Engineering Flow threw porous structures - heterogeneous catalysis Pumps and turbines - Energy- and Environmental Process Engineering Wind- and Wave-Turbines - Renewable Energy
Literature	 Introduction into Computational Fluid Dynamics Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	 Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen Springer Verlag, Berlin, Heidelberg, New York, 2006. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008. Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer- Verlag, Berlin, Heidelberg, 2008. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Literature	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems II Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7
Literature	 [1] Modelica Association: Modelica Language Specification - Version 3.4, Enkloping, Sweden, 2 0 1 7 [2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. [3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. [4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. [5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simul	ation
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0379: Ceramics Tecl	hnology	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Stu	udy Time in Lecture 28
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
	Dr. Rolf Janßen	
Language		
Cycle	WiSe	
Content	based processing, e.g. "powder and cement science as well as	sing with emphasis on advanced structural ceramics. The course focus predominatly on powder- metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass new developments in powderless forming techniques of ceramics and ceramic composites will be iscussed in order to give engineering students an understanding of technology development and components. 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques
Literature	w.D. Kingery, "Introduction to C	Ceramics", John Wiley & Sons, New York, 1975
	ASM Engineering Materials Hand	dbook Vol.4 "Ceramics and Glasses", 1991
	D.W. Richerson, "Modern Ceram	nic Engineering", Marcel Decker, New York, 1992
	Skript zur Vorlesung	

Courses				
Γitle		Тур	Hrs/wk	СР
ntelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4
ntelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
	Vectors, matrices, Calculus			
Knowledge				
	After taking part successfully, students have re	ached the following learning results		
Professional Competence	Students can explain the agent abstraction, de	ting intelligence in terms of rational hobavier	and give detail	a about agont dag
Skills	(goals, utilities, environments). They can descr can be discussed in terms of decision problem world scenarios, students can summarize how formalism in static and dynamic settings. In a settings, with and with complete access to th solving (partially observable) Markov decision Students can identify techniques for simultand desired states. Students can explain coordination of equilibria, social choice functions, voting pro- Students can select an appropriate agent arc students can derive decision trees and apply to networks/dynamic Bayesian networks and ap different sampling techniques for simplified ag- best action or policies for concrete settings. In states,e.g., Nash equilibria. For multi-agent deci- the results.	ns and algorithms for solving these problems Bayesian networks can be employed as a kno iddition, students can define decision making we state of the environment. In this context, problems, and they can recall techniques for eous localization and mapping, and can expla- tor problems and decision making in a multi- atocol, and mechanism design techniques. Intecture for concrete agent application scena pasic optimization techniques. For those appli- popy bayesian reasoning for simple queries. Jeent scenarios. For simple and complex decisi multi-agent situations students will apply tec	For dealing with weldge represen procedures in s students can dea r measuring the ain planning tech gent setting in te arios. For simplifi cations they can Students can a on making stude hniques for findin	h uncertainty in m itation and reason imple and sequen scribe techniques value of informat uniques for achiever of different typ ied agent applicat also create Bayes lso name and ap ints can compute ing different equili
Personal Competence Social Competence	Students are able to discuss their solutions to p	problems with others. They communicate in En	qlish	
Autonomy	Students are able of checking their understand	ing of complex concepts by solving variants of	concrete problei	ms
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
•	Computer Science: Specialisation II: Intelligence			
Following Curricula	International Management and Engineering: Sp	••	e Compulsory	
	Mechatronics: Technical Complementary Cours Mechatronics: Specialisation Intelligent System			
	Biomedical Engineering: Specialisation Artificia		Compulsory	
	Biomedical Engineering: Specialisation Artificia	5 5	comparisony	
	Biomedical Engineering: Specialisation Medical		pulsory	
	Biomedical Engineering: Specialisation Manage			
	Theoretical Mechanical Engineering: Technical		-	
	Theoretical Mechanical Engineering: Specialisa	tion Robotics and Computer Science: Elective	Compulsory	
	Theoretical Mechanical Engineering: Specialisa		C	

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

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

Module M0746: Micro	system Engine	ering				
Courses						
Title				Тур	Hrs/wk	СР
Microsystem Engineering (L0680)				Lecture	2	4
Microsystem Engineering (L0682)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper					
Admission Requirements	None					
Recommended Previous	Basic courses in phys	ics, mathematics	and electric engineering			
Knowledge						
Educational Objectives	After taking part succ	essfully, students	s have reached the follow	ing learning results		
Professional Competence						
Knowledge	The students know a	bout the most ir	mportant technologies a	nd materials of MEMS as well as	their applica	tions in sensors and
	actuators.					
<i></i>						
Skills		analyze and de	escribe the functional b	ehaviour of MEMS components	and to evalu	ate the potential of
	microsystems.					
Personal Competence						
Social Competence	Students are able to s	solve specific prol	blems alone or in a group	and to present the results accor	dingly.	
Autonomy		acquire particula	r knowledge using specia	alized literature and to integrate	and associate	this knowledge with
	other fields.					
Workload in Hours	Independent Study Ti	me 124, Study Ti	me in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation				
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	Electrical Engineering	: Core Qualificati	on: Compulsory			
Following Curricula	International Manage	ment and Engine	ering: Specialisation II. El	ectrical Engineering: Elective Cor	npulsory	
	International Manage	ment and Engine	ering: Specialisation II. M	echatronics: Elective Compulsory		
	Mechanical Engineeri	ng and Managem	ent: Specialisation Mech	atronics: Elective Compulsory		
	Mechatronics: Specia	lisation System D	esign: Elective Compulso	ory		
	Biomedical Engineering	ng: Specialisation	Artificial Organs and Re	generative Medicine: Elective Cor	npulsory	
	Biomedical Engineering	ng: Specialisation	Implants and Endoprost	heses: Elective Compulsory		
	Biomedical Engineering	ng: Specialisation	Medical Technology and	Control Theory: Elective Compul	sory	
	Biomedical Engineering	ng: Specialisation	Management and Busin	ess Administration: Elective Comp	oulsory	
	Microelectronics and	Microsystems: Co	ore Qualification: Elective	Compulsory		
	Theoretical Mechanic	al Engineering: Te	echnical Complementary	Course: Elective Compulsory		
	Theoretical Mechanic	al Engineering: Sp	pecialisation Bio- and Me	dical Technology: Elective Compu	Ilsory	

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

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

Module M0751: Vibra	tion Theory	
Courses		
Title	Typ Hrs/wk CP	
Vibration Theory (L0701)	Integrated Lecture 4 6	
Module Responsible	Prof. Norbert Hoffmann	
Admission Requirements	None	
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics 	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them further.	
Skills	Students are able to denote methods of Vibration Theory and develop them further.	
Personal Competence		
Social Competence	Students can reach working results also in groups.	
Autonomy	Students are able to approach individually research tasks in Vibration Theory.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points	6	
Course achievement	None	
Examination	Written exam	
Examination duration and scale	2 Hours	
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory	
Following Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory	
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: 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 Management and Business Administration: Elective Compulsory	
	Product Development, Materials and Production: Core Qualification: Compulsory	
	Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory	

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

Courses		
Title	Typ Hrs/wk CP	
Finite Element Methods (L0291) Finite Element Methods (L0804)	Lecture 2 3 Recitation Section (large) 2 3	
Module Responsible		
Admission Requirements		
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)	
Kilowiedge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to	give
	overview of the theoretical and methodical basis of the method.	
Chille	The students are canable to bandle anginaging problems by formulating suitable finite elements, accompling the correspondence of the second statements and the second statements are second statements and the second statements are second statements are second statements and the second statements are second statements and statements are second statements are s	nond
SKIIIS	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corres	pond
	system matrices, and solving the resulting system of equations.	
Personal Competence		
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.	
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element i	outir
	Problems can be identified and the results are critically scrutinized.	
	robienis can be identified and the results are endeally serutifized.	
	riobens can be recipined and the results are enticary serutinized.	
	riobens can be recipined and the results are entically serucinized.	
Workload in Hours		
Workload in Hours Credit points	Independent Study Time 124, Study Time in Lecture 56	
	Independent Study Time 124, Study Time in Lecture 56 6	
Credit points	Independent Study Time 124, Study Time in Lecture 56 6	
Credit points	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm	
Credit points Course achievement	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm Written exam	
Credit points Course achievement Examination	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm Written exam 120 min	
Credit points Course achievement Examination Examination duration and scale	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm Written exam 120 min	
Credit points Course achievement Examination Examination duration and scale	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Written exam 120 min Civil Engineering: Core Qualification: Compulsory	
Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Written exam 120 min Civil Engineering: Core Qualification: Compulsory	
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Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory	
Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory	
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Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form No 20 % Midterm Written exam 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory	
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Course L0291: Finite Element Methods	
	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	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

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Courses						
Title				Тур	Hrs/wk	СР
Microsystems Technology (L0724) Microsystems Technology (L0725)				Lecture Project-/problem-based Learning	2 2	4
Module Responsible	Prof. Hoc Khiem Trieu					
	None					
Recommended Previous	Basics in physics, cher	mistry, mechanics and s	semiconductor techr	nology		
Knowledge						
Educational Objectives	After taking part succe	essfully, students have	reached the followin	ig learning results		
Professional Competence						
Knowledge	Students are able					
				or microstructures and especia of in more complex systems	Ily methods f	or the fabrication
	to explain in detai	ils operation principles (of microsensors and	microactuators and		
	to discuss the pote	ential and limitation of	microsystems in app	olication.		
Skills	Students are capable					
	 to analyze the fea 	sibility of microsystems	5,			
	-	s flows for the fabricati		es and		
	 to apply them. 					
Personal Competence Social Competence						
	Students are able to p of audience.	prepare and perform the	eir lab experiments i	in team work as well as to prese	ent and discus	s the results in fro
Autonomy	None					
Workload in Hours	Independent Study Tin	me 124, Study Time in I	Lecture 56			
Credit points						
Course achievement	Compulsory Bonus Yes None	Form Subject theoretical practical work		führen in Kleingruppen ein La nd diskutiert die Theorie sowie o mten Kurs.		
Examination	Oral exam					
Examination duration and scale	30 min					
-	Electrical Engineering: International Managen Biomedical Engineerin Biomedical Engineerin	: Specialisation Medical ment and Engineering: S ng: Specialisation Artific ng: Specialisation Implan	Technology: Elective Specialisation II. Mec ial Organs and Rege nts and Endoprosthe	hatronics: Elective Compulsory nerative Medicine: Elective Con eses: Elective Compulsory	npulsory	
	Biomedical Engineerin		gement and Busines	Control Theory: Elective Compuls s Administration: Elective Comp ompulsory	-	

Course L0724: Microsystems	Technology
-	Lecture
Hrs/wk	
СР	
	Independent Study Time 92, Study Time in Lecture 28
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics. Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering: CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, crop 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, rajd prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process) Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensor: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actua
	TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Course L0725: Microsystems	ourse L0725: Microsystems Technology		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Hoc Khiem Trieu		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

yp oject-/problem-based Learning oject-/problem-based Learning learning results	Hrs/wk 3 2	CP 3 3	
oject-/problem-based Learning roject-/problem-based Learning	3	3	
oject-/problem-based Learning			
	2	3	
learning results			
)			
• Technology Funding & Controlling			
Management on a national as	well as intern	ational loval	
Management - on a national as			
 Equip students with an understanding of important elements of Technology Management (strategic, ope organizational and process-related aspects) 			
innovation process as well as	Technoloav M	lanagement and	
 Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management ar importance for corporate strategy 			
Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation)			
• Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issue			
Further topics to be discussed	include:		
ant of technology, R&D and inr	ovation		
ent of technology, R&D and Im	lovacion		
y and Innovation Management	ī.		
,			
ves Management: Elective Com	npulsory		
ent: Elective Compulsory			
	nulcony		
erative Medicine: Elective Com	puisory		
erative Medicine: Elective Com es: Elective Compulsory ntrol Theory: Elective Compuls			
	innovation process as well as y sourcing, maintenance and e derstanding of managerial, o . Further topics to be discussed ent of technology, R&D and inr gy and Innovation Management gy and Innovation Management ent: Elective Compulsory	innovation process as well as Technology M y sourcing, maintenance and exploitation) derstanding of managerial, organizational of . Further topics to be discussed include: ent of technology, R&D and innovation gy and Innovation Management 	

Course L0849: Technology M	lanagement
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	The role of technology for the competitive advantage of the firm and industries; Basic concepts, models and tools for the management of technology; managerial decision making regarding the identification, selection and protection of technology (make or buy, keep or sell, current and future technologies). Theories, practical examples (cases), lectures, interactive sessions and group study. This lecture is part of the Module Technology Management and can not separately choosen.
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	anagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Courses					
Fitle		Typ	Hrs/wk	СР	
Control Systems Theory and Design	(L0656)	Typ Lecture	2	4	
Control Systems Theory and Design		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 following learning results			
Professional Competence					
Knowledge	 Students can explain how linear dyna 	mic systems are represented as state space r	models: they can	interpret the sys	
	response to initial states or external ex		nodels, they can	interpret the sys	
		es controllability and observability, and their re	lationship to stat	e feedback and s	
	estimation, respectively				
	 They can explain the significance of a r 	minimal realisation			
		feedback and how it can be used to achieve tr	acking and distur	bance rejection	
	They can extend all of the above to mu	ılti-input multi-output systems			
	They can explain the z-transform and i	ts relationship with the Laplace Transform			
	 They can explain state space models a 	nd transfer function models of discrete-time sy	stems		
	They can explain the experimental iden	ntification of ARX models of dynamic systems, a	and how the iden	tification problem	
	be solved by solving a normal equation				
	 They can explain how a state space module 	odel can be constructed from a discrete-time in	npulse response		
Skills					
	 Students can transform transfer function models into state space models and vice versa They can assess controllability and observability and construct minimal realisations 				
	 They can assess controllability and observability and construct minimal realisations They can design LQG controllers for multivariable plants 				
	 They can design LGG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropria 				
	for a given sampling rate				
	 They can identify transfer function models and state space models of dynamic systems from experimental data 				
		ing standard software tools (Matlab Control To			
	Simulink)				
Personal Competence					
Social Competence	Students can work in small groups on specific	problems to arrive at joint solutions.			
Autonomy	Students can obtain information from provid	ded sources (lecture notes, software documen	tation, experime	nt guides) and u	
	when solving given problems.				
	They can assess their knowledge in weekly or	n-line tests and thereby control their learning p	rogross		
	They can assess their knowledge in weekly of	inne tests and thereby control their learning p	logress.		
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56			
Credit points	6				
Course achievement	None				
Examination					
Examination duration and	120 min				
scale					
Assignment for the	Electrical Engineering: Core Qualification: Cor	npulsory			
Following Curricula	Energy Systems: Core Qualification: Elective	Compulsory			
	Aircraft Systems Engineering: Specialisation A	Aircraft Systems: Compulsory			
	Aircraft Systems Engineering: Specialisation A	Avionic Systems: Elective Compulsory			
	Computational Science and Engineering: Spec	cialisation II. Engineering Science: Elective Com	pulsory		
	International Management and Engineering: S	Specialisation II. Electrical Engineering: Elective	Compulsory		
	International Management and Engineering: S	Specialisation II. Mechatronics: Elective Compute	sory		
	Mechanical Engineering and Management: Sp	ecialisation Mechatronics: Elective Compulsory			
	Mechatronics: Core Qualification: Compulsory				
	Biomedical Engineering: Specialisation Artifici	ial Organs and Regenerative Medicine: Elective	Compulsory		
	Biomedical Engineering: Specialisation Implar				
		al Technology and Control Theory: Compulsory			
		gement and Business Administration: Elective C	compulsory		
	Product Development, Materials and Producti				
	Product Development, Materials and Producti Theoretical Mechanical Engineering: Core Qua				

Course L0656: Control Syste	ms Theory and Design	
Тур	Lecture	
Hrs/wk	2	
СР	4	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	State space methods (single-input single-output)	
	State space models and transfer functions, state feedback	
	Coordinate basis, similarity transformations	
	 Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem 	
	Controllability and pole placement	
	State estimation, observability, Kalman decomposition	
	Observer-based state feedback control, reference tracking	
	Transmission zeros	
	Optimal pole placement, symmetric root locus	
	Multi-input multi-output systems	
	Transfer function matrices, state space models of multivariable systems, Gilbert realization	
	Poles and zeros of multivariable systems, minimal realization	
	Closed-loop stability	
	Pole placement for multivariable systems, LQR design, Kalman filter	
	Digital Control	
	Discrete-time systems: difference equations and z-transform	
	 Discrete-time state space models, sampled data systems, poles and zeros 	
	 Frequency response of sampled data systems, choice of sampling rate 	
	System identification and model order reduction	
	Least squares estimation, ARX models, persistent excitation	
	 Identification of state space models, subspace identification 	
	Balanced realization and model order reduction	
	Case study	
	 Modelling and multivariable control of a process evaporator using Matlab and Simulink 	
	Software tools	
	• Matlab/Simulink	
Literature		
	Werner, H., Lecture Notes "Control Systems Theory and Design"	
	T. Kailath "Linear Systems", Prentice Hall, 1980	
	K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997	
	L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999	

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

C				
Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0932)	2220	Lecture	2	2
Production Planning and Control (L Production Planning and Control (L		Lecture Recitation Section (small)	2 1	2 1
Exercise: The Digital Enterprise (L0		Recitation Section (small)	1	1
	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	Management		
Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the	module in detail and take a critical position to them		
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineer	ing: Specialisation II. Product Development and Product	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spo	ecialisation Production and Logistics: Elective Compu	lsory	
	Biomedical Engineering: Specialisation A	rtificial 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 Management and Business Administration: Compulsory		ГУ		
	Product Development, Materials and Pro	duction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Pro	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Pro	duction: Specialisation Materials: Elective Compulsor	У	
	Theoretical Mechanical Engineering: Spe	cialisation Product Development and Production: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	iterprise
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered. Content: • Business Process Management and Data Modelling, Simulation • Knowledge and Competence Management • Process Management (PPC, Workflow Management) • Computer Aided Planning (CAP) and NC-Programming • Virtual Reality (VR) and Augmented Reality (AR) • Computer Aided Quality Management (CAQ) • Industry 4.0
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002 Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006 Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004 Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007 Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006

Course L0929: Production Pla	anning and Control
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002

Course L0930: Production Pl	ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0933: Exercise: The	Digital Enterprise
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	Siehe korrespondierende Vorlesung
	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
Electronic Circuits for Medical Appli		Lecture	2	3
Electronic Circuits for Medical Appli		Recitation Section		2
Electronic Circuits for Medical Appli		Practical Course	1	1
Module Responsible				
Admission Requirements				
	Fundamentals of electrical engineering			
Knowledge				
Educational Objectives	After taking part successfully, students ha	ve reached the following learning result	.S	
Professional Competence				
Knowledge	 Students can explain the basic fund 	tionality of the information transfer by t	the central nervous system	
		ild-up of an action potential and its prop		
		nication between neurons and electroni		
		eatures of low-noise amplifiers for medic		
	 Students can explain the functions 			
		tential and limitations of cochlea implan	its and artificial eves	
Skills				
SKIIS	 Students can calculate the time d 	ependent voltage behavior of an action	potential	
	 Students can give scenarios for fur 	her improvement of low-noise and low-	power signal acquisition.	
	 Students can develop the block dia 	grams of prosthetic systems		
	 Students can define the building bl 	ocks of electronic systems for an articifia	al eye.	
Personal Competence				
Social Competence				111 - 1155 -
		plems in the field of medical electronic	in teams together with	experts with differ
	professional background.		. Constant of the state of the state	
		r specific limitations, so that they can as		
		in a clear manner and communicate the	heir results in a way that o	stners can be invol
	whenever it is necessary			
4				
Autonomy	• Students are able to realistically	judge the status of their knowledge	and to define actions fo	r improvements w
	necessary.			
	 Students can break down their wor 	k in appropriate work packages and sch	edule their work in a realist	tic way.
	 Students can handle the complex c 	ata structures of bioelectrical experime	nts without needing suppor	t.
	 Students are able to act in a response 	sible manner in all cases and situations	of experimental work.	
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement		Description		
	Yes None Subject theoreti	cal and		
	practical work			
	No None Excercises			
Examination				
Examination duration and	90 min			
scale				
•	Electrical Engineering: Specialisation Med			
Following Curricula	Biomedical Engineering: Specialisation Ar			
	Biomedical Engineering: Specialisation Im			
	Biomedical Engineering: Specialisation Me			
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration	: Elective Compulsory	
	Microelectronics and Microsystems: Speci			
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective C	ompulsory	
	Theoretical Mechanical Engineering: Spec	alisation Bio- and Medical Technology	Elective Compulsory	

Course L0696: Electronic Cire	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	 Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Cire	ourse L1056: Electronic Circuits for Medical Applications	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Matthias Kuhl	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1408: Electronic Cire	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Module M1150: Conti	nuum Mechanics			
- -				
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533) Continuum Mechanics Exercise (L1	534)	Lecture Recitation Section (small)	2 2	3 3
Module Responsible		Rectation Section (Small)	L	5
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e	a in the module Mechanics II (forces and	d moments stre	ss linear strain fre
Knowledge	-	•	a momento, stre	ss, mear strain, ne
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concept	s to calculate the mechanical behavior of r	naterials.	
Skills	The students can set up balance laws and apply b	pasics of deformation theory to specific as	spects both in a	nnlied contexts as
Skiiis	research contexts.	disies of deformation theory to specific d	speces, both in a	pplied contexts as
Personal Competence				
Social Competence	The students are able to develop solutions, to pres	ent them to specialists in written form and	to develop ideas	s further.
Autonomy	The students are able to assess their own strength	s and weaknesses. They can independent	ly and on their o	wn identify and sol
	problems in the area of continuum mechanics and	acquire the knowledge required to this end	d.	
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective	Compulsory		
Following Curricula	Mechanical Engineering and Management: Speciali	sation Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: E	lective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	hnology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Managemer	nt and Business Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Co	ore Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualifica	tion: Elective Compulsory		

Course L1533: Continuum Me	ourse L1533: Continuum Mechanics		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Christian Cyron		
Language	DE		
Cycle	WiSe		
Content	 kinematics of undeformed and deformed bodies balance equations (balance of mass, balance of energy,) stress states material modelling 		
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer		

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

	rial Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum m	nechanics as taught, e.g., in the modules Mechanic	s II and Continuu	ım Mechanics (for
Knowledge	and moments, stress, linear and nonlinear	strain, free-body principle, linear and nonlinear cor	nstitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students hav	ve reached the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals	of multidimensional consitutive material laws		
Skills	The students can implement their own mat	terial laws in finite element codes. In particular, th	e students can a	pply their knowle
	to various problems of material science and	d evaluate the corresponding material models.		
Personal Competence				
		to present them to specialists and to develop idea	as further.	
Autonomy		strengths and weaknesses. They can independent and acquire the knowledge required to this end.	ly and on their ov	wn identify and s
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling:	Elective Compulsory		
Following Curricula	Mechanical Engineering and Management:	Specialisation Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artif	ficial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Imp	lants and Endoprostheses: Elective Compulsory		
			pulsory	
	Biomedical Engineering: Specialisation Med	lical Technology and Control Theory: Elective Com	paiboly	
		lical Technology and Control Theory: Elective Com nagement and Business Administration: Elective Co		
	Biomedical Engineering: Specialisation Man			
	Biomedical Engineering: Specialisation Man Product Development, Materials and Produc	nagement and Business Administration: Elective Co		

Course L1535: Material Modeling		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials) - plasticity (permanent deformation due to one-time overload, e.g., in metal forming) - viscoelasticity (absorption of energy, e.g., in dampers) - creep (slow deformation under permanent load, e.g., in pipes)	
	This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.	
Literature		

Course L1536: Material Mode	urse L1536: Material Modeling	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1199: Adva	nced Functional Materials			
Courses				
Title	() () () () () () () () () () () () () (Typ Seminar	Hrs/wk	СР б
Advanced Functional Materials (L1)		Seminar	2	6
Module Responsible Admission Requirements				
	Basic knowledge in Materials Science, e.g.	Materials Science I/II		
Knowledge	busic knowledge in Materials Science, e.g			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particul metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.			
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design ner materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview o modern materials science, which enables them to select optimum materials combinations depending on the technica applications.			
Personal Competence				
Social Competence	The students are able to present solution	s to specialists and to develop ideas further.		
Autonomy	The students are able to			
	assess their own strengths and weaknesses.			
	gather new necessary expertise by	/ their own.		
Workload in Hours	Independent Study Time 152, Study Time	e in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Materials Science: Core Qualification: Cor	npulsory		
Following Curricula		t: Specialisation Materials: Elective Compulsor		
	• • •	tificial Organs and Regenerative Medicine: Ele		
		pplants and Endoprostheses: Elective Compuls		
	• • •	edical Technology and Control Theory: Elective		
		anagement and Business Administration: Elect		
		nnical Complementary Course: Elective Compu	•	
	Theoretical Mechanical Engineering: Spec	cialisation Materials Science: Elective Compuls	ory	

Course L1625: Advanced Functional Materials		
Тур	Seminar	
Hrs/wk	2	
СР	6	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Christian Cyron, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Stefan Fritz Müller	
Language	DE	
Cycle	WiSe	
Content	1. Porous Solids - Preparation, Characterization and Functionalities	
	2. Fluidics with nanoporous membranes	
	3. Thermoplastic elastomers	
	4. Optimization of polymer properties by nanoparticles	
	5. Fiber composites in automotive	
	6. Modeling of materials based on quantum mechanics	
	7. Biomaterials	
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.	

Module M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antenr	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
-	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro		Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic		Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
Ū.	Biomedical Engineering: Specialisation Medical Techn		pulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			

Course L1663: Nature's Hierarchical Materials		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and		
scale		
Lecturer	Prof. Gerold Schneider	
Language	EN	
Cycle	WiSe	
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc. This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.	
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications	

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
	Lecture
Hrs/wk	
CP	
	T Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and	
scale	30 (1)(1)
-	Prof. Christian Schuster
Language	
Cycle	
-	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as
Content	Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency
	/ high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation
	and Electromagnetic Compatibility will be introduced and discussed.
	Topics:
	- Fundamental properties and phenomena of electrical circuits
	- Steady-state sinusoidal analysis of electrical circuits
	- Fundamental properties and phenomena of electromagnetic fields and waves
	- Steady-state sinusoidal description of electromagnetic fields and waves
	- Useful microwave network parameters
	- Transmission lines and basic results from transmission line theory
	- Plane wave propagation, superposition, reflection and refraction
	- General theory of waveguides
	- Most important types of waveguides and their properties
	- Radiation and basic antenna parameters
	- Most important types of antennas and their properties
	- Numerical techniques and CAD tools for waveguide and antenna design
	- Fundamentals of Electromagnetic Compatibility
	- Coupling mechanisms and countermeasures
	- Shielding, grounding, filtering
	- Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1588: Development	and Regulatory Approval of Implants
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 	
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009	

Course L1890: Seminar Biomedical Engineering		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

Course L1130: Six Sigma	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

Course L0001: Fluid Mechani	ics II
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	 Differential equations for momentum-, heat and mass transfer Examples for simplifications of the Navier-Stokes Equations
	 Unsteady momentum transfer Free shear layer, turbulence and free jets Flow around particles - Solids Process Engineering Coupling of momentum and heat transfer - Thermal Process Engineering
	 Rheology - Bioprocess Engineering Coupling of momentum- and mass transfer - Reactive mixing, Chemical Process Engineering Flow threw porous structures - heterogeneous catalysis Pumps and turbines - Energy- and Environmental Process Engineering Wind- and Wave-Turbines - Renewable Energy Introduction into Computational Fluid Dynamics
Literature	 Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen Springer Verlag, Berlin, Heidelberg, New York, 2006. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV
	 Fachverlage GmbH, Wiesbaden, 2008. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner, GWV Fachverlage GmbH, Wiesbaden, 2009. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Literature	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems II Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7
Literature	 Modelica Association. Modelica Language Specification - Version 3.4 , Enkoping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simul	ourse L1821: System Simulation	
Тур	Recitation Section (large)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0379: Ceramics Tecl	hnology			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Stu	ndependent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur			
Examination duration and	90 Minuten			
scale				
Lecturer	Dr. Rolf Janßen			
Language	DE/EN			
Cycle	WiSe			
Content	 I/Se itroduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on pow assed processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of g nd cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites wi ddressed Examples will be discussed in order to give engineering students an understanding of technology development becific applications of ceramic components. ontent: Introduction Introduction Raw materials Powder processing Shape-forming processes Densification, sintering Glass and Cement technology 8. Ceramic-metal joining techniques 			
Literature		Ceramics", John Wiley & Sons, New York, 1975 dbook Vol.4 "Ceramics and Glasses", 1991		
	D.W. Richerson, "Modern Ceran	nic Engineering", Marcel Decker, New York, 1992		
	Skript zur Vorlesung			

Courses					
Title		Тур	Hrs/wk	СР	
Introduction to Biochemistry and M	olecular Biology (L0386)	Lecture	2	3	
Module Responsible	Prof. Hans-Jürgen Kreienkamp				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge	The students can				
	 describe basic biomolecules; 				
	 explain how genetic information is 	s coded in the DNA:			
	 explain the connection between D 				
Skills	The students can				
	 recognize the importance of molecular parameters for the course of a disease; 				
	 describe selected molecular-diagn 				
	 explain the relevance of these pro 				
Personal Competence					
Social Competence	The students can participate in discussio	ns in research and medicine on a technical le	vel.		
Autonomy	The students can develop understanding	of topics from the course, using technical lite	erature, by themselves.		
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28			
Credit points					
Course achievement					
Examination					
Examination duration and					
scale	oo minutes				
	General Engineering Science (German pr	ogram, 7 semester): Specialisation Biomedica	A Engineering: Compulsory		
Following Curricula		program, 7 semester): Specialisation Medica			
r onowing curricula	Compulsory	program, 7 semestery. Specialisation met	endinedi Engineering, roe	us biomeenum	
	Data Science: Specialisation Medicine: Co	ompulsory			
	Electrical Engineering: Specialisation Me				
	Engineering Science: Specialisation Biom				
		ogram, 7 semester): Specialisation Biomedical	l Engineering: Compulsory		
		program, 7 semester): Specialisation Med		us Biomechani	
	Compulsory				
	Mechanical Engineering: Specialisation B	iomechanics: Compulsory			
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Elec	ctive Compulsory		
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: El	ective Compulsory		
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Electiv	ve Compulsory		
	Biomedical Engineering: Specialisation Ir	nplants and Endoprostheses: Elective Compul	sory		
	Technomathematics: Specialisation III. En	ngineering Science: Elective Compulsory			

se L0386: Introduction t	to Biochemistry and Molecular Biology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008

C				
Courses				
Title		Тур	Hrs/wk	СР 3
Implants and Fracture Healing (L03		Lecture	2	3
Module Responsible				
Admission Requirements				
	It is recommended to participate in "Introduction int	o Anatomie" before attending "Imp	lants and Fracture Heali	ng".
Knowledge				
-	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how b			
	The students can name different treatments for the	spine and hollow bones under give	n fracture morphologies	
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			ic assumptions.
Personal Competence				
Social Competence	The students can, in groups, solve basic numerical r	nodeling tasks for the calculation o	f internal forces.	
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 3	28		
Credit points				
Course achievement				
Examination				
Examination duration and				
scale	50 mm			
	General Engineering Science (German program,	7 semester): Specialisation Mer	hanical Engineering E	ocus Biomechan
Following Curricula		, semester). Specialisation nee	indifical Engineering, 19	beas biomeenan
· ····································	General Engineering Science (German program, 7 se	emester): Specialisation Biomedica	l Engineering: Compulso	rv
	Engineering Science: Specialisation Biomedical Engi		·	. ,
	General Engineering Science (English program, 7 se		Engineering: Compulsor	v
	General Engineering Science (English program,			
	Compulsory	, semester). Specialisation mee	indifical Engliteening, it	beus bioincenan
	Mechanical Engineering: Specialisation Biomechanic	s: Compulsory		
	Biomedical Engineering: Specialisation Donicelland		active Compulsory	
		-		
	Biomedical Engineering: Specialisation Implants and		-	
	Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Management		tive compulsory	
	Orientierungsstudium: Core Qualification: Elective C	ompulsory		
	Technomathematics: Specialisation III. Engineering			

Тур	Fracture Healing Lecture
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	
Content	Topics to be covered include:
	1. Introduction (history, definitions, background importance)
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)
	3.1 The spine in its entirety
	3.2 Cervical spine
	3.3 Thoracic spine
	3.4 Lumbar spine
	3.5 Injuries and diseases
	4. Pelvis (anatomy, biomechanics, fracture treatment)
	5 Fracture Healing
	5.1 Basics and biology of fracture repair
	5.2 Clinical principals and terminology of fracture treatment
	5.3 Biomechanics of fracture treatment
	5.3.1 Screws
	5.3.2 Plates
	5.3.3 Nails
	5.3.4 External fixation devices
	5.3.5 Spine implants
	6.0 New Implants
Literature	Cochran V.B.: Orthopädische Biomechanik
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgio	al techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge		of the human body and the materials being	used in medical engineer	ing, and their field
	use.			
Skills	The students can explain the advantages	and disadvantages of different kinds of bio	materials.	
Personal Competence				
Social Competence The students are able to discuss issues related to materials being present or being used for replacements with the teachers.			th student mates a	
	the teachers.			
Autonomy	The students are able to acquire informat	ion on their own. They can also judge the in	formation with respect to	o its credibility.
Workload in Hours	Independent Study Time 62, Study Time	n Lecture 28		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineeri	ng: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano an	d Hybrid Materials: Elective Compulsory		
		tificial Organs and Regenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Im			
		edical Technology and Control Theory: Elect		
		anagement and Business Administration: Ele		
	5 5	nical Complementary Course: Elective Com cialisation Bio- and Medical Technology: Elec	, ,	

Course L0593: Biomaterials	Lashura
l yp Hrs/wk	Lecture
CP	
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	Topics to be covered include:
	1. Introduction (Importance, nomenclature, relations)
	2. Biological materials
	2.1 Basics (components, testing methods)2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which ar used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
Literature	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.

Module M1342: Polyr				
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polyme Processing and design with polyme		Lecture	2	3 3
Module Responsible				-
Admission Requirements				
Recommended Previous	Basics: chemistry / physics / material scie	ence		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plastic	cs and define the necessary testing and analys	is.	
	They can explain the complex relationship	ps structure-property relationship and		
	the interactions of chemical structure of t	he polymers, including to explain neighboring	contexts (e.g. sustaina	ability, environment
	protection).			
Skille	Students are capable of			
JKIIIS				
	-	ds in a given context to mechanical proper	ties (modulus, streng	th) to calculate a
	evaluate the different materials.			
	- selecting appropriate solutions for mech	hanical recycling problems and sizing example	stiffness, corrosion re	sistance.
Personal Competence				
Social Competence				
	arrive at funded work results in betarag	onius groups and document them		
	- arrive at funded work results in heteroge	enius groups and document them.		
	- provide appropriate feedback and handl	e feedback on their own performance construc	tively.	
Autonomi	Students are able to			
Autonomy				
	- assess their own strengths and weaknes	sses.		
	- assess their own state of learning in specific terms and to define further work steps on this basis.			
	- assess possible consequences of their p	rofessional activity.		
Workload in Hours		e in Lecture 56		
Credit points				
Course achievement Examination				
Examination duration and				
scale				
Assignment for the	Materials Science: Specialisation Enginee	ring Materials: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Compulsory		
		tificial Organs and Regenerative Medicine: Elec		
		anagement and Business Administration: Electi		
		edical Technology and Control Theory: Elective luction: Specialisation Production: Elective Com		
		luction: Specialisation Materials: Elective Comp		
		luction: Specialisation Product Development: El	-	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compul	sory	
	Theoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compulso	iry	

Course L0389: Structure and	Departies of Delymout
	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Dr. Hans Wittich
Language	
Cycle	
	- Structure and properties of polymers
	 Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution Morphology amorph, crystalline, blends Properties
	Elasticity, plasticity, viscoelacity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Processing an	nd design with polymers
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich
Language	DE/EN
Cycle	WiSe
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining
	Designing with Polymers: Materials Selection; Structural Design; Dimensioning
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag
	Crawford: Plastics engineering, Pergamon Press
	Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag
	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Courses								
Title			Тур	Hrs/wk	СР			
Regenerative Medicine (L0347) Lecture Tissue Engineering - Rege	porativo Modicipo (L166)	4)	Seminar Seminar	2	3 3			
		+)	Seminar	Σ	5			
Module Responsible								
Admission Requirements								
Recommended Previous	None							
Knowledge		cossfully, students have	ve reached the following learning results					
		cessfully, students hav	ve reached the following learning results					
Professional Competence Knowledge	e After successful completion of the module students will be able to describe the basic methods of regenerative medicine explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of met							
	the cultivation of animal and human cells. The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the ba udnerlying principles of the discussed topics.							
Skills	 After successful completion of the module students are able to use medical databases for acquirierung and presentation of relevant up-to-date data independently able to present their work results in the form of presentations able to carry out basic cell culture methods and the corresponding analysis independently able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 							
Personal Competence Social Competence	Students are able to defend them.		am with 2-4 students to solve given tasks and with 2-4 students to solve given tasks and te		in the plenary and			
Autonomy	After completion of		pants will be able to solve a technical		approx. 2-4 perso			
Workload in Hours	Independent Study T	ime 124, Study Time	in Lecture 56					
Credit points	6							
Course achievement	CompulsoryBonusYes20 %	Form Written elaboration	Description Ausarbeitung zu Ringvorlesung / p	protocol for lecture series				
Examination	Presentation							
Examination duration and scale	Oral presentation + o	discussion (30 min)						
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory							

Course L0347: Regenerative	Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
	The course deals with the application of biotechnological engineering principles for re-generation of human tissues. The main topics are "tissue engineering" for the generation of "artificial organs" such as cartilage, liver, blood vessel etc., and their applications: • Introduction (historical development, examples for medical and technical applications, commercial aspets) • Cell specific fundamentals (cell physiology, biochemistry, metabolism, special requirements for cell cultivation "in vitro") • Process specific fundamentals (requirements for culture systems, examples for reactor design, mathematical modelling, process and control strategies) • Examples for applications for clinical applications, drug testing and material testing The fundamentals will be presented by the lecturers. The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Course L1664: Lecture Tissu	ourse L1664: Lecture Tissue Engineering - Regenerative Medicine				
Тур	Seminar				
Hrs/wk	2				
СР	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock				
Language	DE				
Cycle	WiSe				
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts				
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716				
	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540				

Courses							
Title					Тур	Hrs/wk	СР
Robotics and Navigation in Medicine (L0335)					Lecture	2	3
Robotics and Navigation in Medicine (L0338)					Project Seminar	2	2
Robotics and Navigation in Medicin	e (L0336)				Recitation Section (small)	1	1
Module Responsible	Prof. Alexa	Prof. Alexander Schlaefer					
Admission Requirements	None						
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) 						
	 solid 	d R or Matla	ab skills				
Educational Objectives	After taking	g part succ	essfully, students	nave reached the follow	wing learning results		
Professional Competence		-	-				
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typics systems regarding design and limitations. The students are able to design and evaluate navigation systems and robotic systems for medical applications.						
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.						
Workload in Hours	Independer	nt Study Tir	me 110, Study Tin	e in Lecture 70			
Credit points	6						
Course achievement	Compulsory Yes Yes	Bonus 10 % 10 %	Form Written elaborati Presentation	Description ON			
Examination	Written exa	am					
Examination duration and	90 minutes	S					
scale	ļ						
-				lligence Engineering: E			
Following Curricula				dical Technology: Elec			
					Electrical Engineering: Elective		Commulation
		-	-	Systems and Robotics:	Process Engineering and Biotec	chhology: Elective	Compulsory
						Compulson	
	Diometrical	-		-	egenerative Medicine: Elective theses: Elective Compulsory	Compuisory	
	Biomedical		ig. specialisation	inplaints and Endoprost	cheses. Elective compulsory		
		-	ng: Specialisation I	1edical Technology and	d Control Theory: Elective Com	nulsory	
	Biomedical	l Engineerin			d Control Theory: Elective Com ness Administration: Elective C		
	Biomedical Biomedical	l Engineerin I Engineerin	ng: Specialisation I	lanagement and Busin	ness Administration: Elective C	ompulsory	
	Biomedical Biomedical Product De	l Engineerin l Engineerin evelopment,	ng: Specialisation I , Materials and Pro	Aanagement and Busin duction: Specialisation		ompulsory ve Compulsory	
	Biomedical Biomedical Product De Product De	l Engineerin l Engineerin evelopment, evelopment,	ng: Specialisation I , Materials and Pro , Materials and Pro	Aanagement and Busin duction: Specialisation duction: Specialisation	ness Administration: Elective C n Product Development: Electiv	ompulsory ve Compulsory ory	
	Biomedical Biomedical Product De Product De Product De	I Engineerin I Engineerin evelopment, evelopment,	ng: Specialisation I , Materials and Pro , Materials and Pro , Materials and Pro	Aanagement and Busin duction: Specialisation duction: Specialisation duction: Specialisation	ness Administration: Elective C n Product Development: Electiv n Production: Elective Compuls	ompulsory ve Compulsory ory	

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

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

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

Courses				
		-	11	
Title	icine and Tissue Engineering (L1963)	Typ Seminar	Hrs/wk 3	CP 6
-		Seminar	3	0
Module Responsible				
Admission Requirements	None			
Recommended Previous				
Knowledge				
	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in Le	cture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artificia	l Organs and Regenerative Medicine: C	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compu	llsory	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Medica	Technology and Control Theory: Elect	ve Compulsory	

Course L1963: Case Studies	ourse L1963: Case Studies for Regenerative Medicine and Tissue Engineering				
Тур	Seminar				
Hrs/wk	3				
СР	6				
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42				
Lecturer	of. Ralf Pörtner, Prof. Michael Morlock				
Language	DE				
Cycle	SoSe				
Content					
Literature					

Module M0634: Introd	luction	into Me	dical Technology	y and System	ns		
Courses							
Title					Тур	Hrs/wk	СР
Introduction into Medical Technolog	- duction into Medical Technology and Systems (L0342)				Lecture	2	3
roduction into Medical Technology and Systems (L0343) Project Seminar 2					2		
Introduction into Medical Technolog	y and Systems (L1876) Recitation Section (large) 1 1						1
Module Responsible	Prof. Alexander Schlaefer						
Admission Requirements	None	None					
Recommended Previous							
Knowledge							
	principles of	of program	ming, R/Matlab				
Educational Objectives	After takin	g part succ	essfully, students have r	eached the follow	ing learning results		
Professional Competence							
Knowledge	The stude	nts can ex	plain principles of medi	ical technology, i	ncluding imaging systems,	computer aided s	urgery, and medica
	information	n systems.	They are able to give an	overview of regul	latory affairs and standards i	n medical technol	ogy.
Skille	The studer	ate are able	to ovaluato systems an	d modical dovicos	in the context of clinical and	lications	
SKIIIS	The studer	its are able	e to evaluate systems and	u medical devices	in the context of clinical app	JICALIONS.	
Personal Competence							
Social Competence	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.						
Autonomy	The studer	nts can ref	lect their knowledge and	l document the re	sults of their work. They ca	n present the resu	ults in an appropriate
hatohomy	manner.		leet their knowledge und		Suits of their work. They ca	in present the rest	
Workload in Hours	Independe	Independent Study Time 110, Study Time in Lecture 70					
Credit points							
Course achievement	Compulsory Yes	Bonus 10 %	Form Written elaboration	Description			
	Yes	10 %	Presentation				
Examination	Written exa						
Examination duration and							
scale	o o minaces	-					
Assignment for the	General En	gineering	Science (German program	m, 7 semester): Sp	pecialisation Biomedical Engi	neering: Compuls	ory
Following Curricula					eering: Elective Compulsory		
	Computer	Science: S	pecialisation II. Mathema	tics and Engineeri	ng Science: Elective Compul	sory	
	Data Scien	ice: Core Q	ualification: Elective Com	npulsory			
	Electrical E	Engineering	: Core Qualification: Elec	ctive Compulsory			
	-		Specialisation Biomedica				
					ecialisation Biomedical Engir		
					ematics & Engineering Scien		ulsory
			5 5 1		er Science: Elective Compuls	5	
			• • •	÷	ring Sciences: Elective Comp generative Medicine: Elective	-	
		-	•		neses: Elective Compulsory	compuisory	
					Control Theory: Elective Cor	npulsory	
		-	•		-		
			Specialisation III. Engine			. ,	
	Biomedica	l Engineeri	ng: Specialisation Manag	ement and Busine	ess Administration: Elective C		

Course L0342: Introduction i	ourse L0342: Introduction into Medical Technology and Systems					
Тур	Lecture					
Hrs/wk	2					
СР	\$					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Alexander Schlaefer					
Language	DE					
Cycle	SoSe					
Content	- imaging systems					
	- computer aided surgery					
	- medical sensor systems					
	- medical information systems					
	- regulatory affairs					
	- standard in medical technology					
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.					
Literature	Wird in der Veranstaltung bekannt gegeben.					

Course L0343: Introduction i	ourse L0343: Introduction into Medical Technology and Systems		
Тур	Project Seminar		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction i	nto Medical Technology and Systems		
Тур	tation Section (large)		
Hrs/wk	1		
CP			
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	- imaging systems		
	- computer aided surgery		
	- medical sensor systems		
	dical information systems		
	gulatory affairs		
	- standard in medical technology		
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.		
Literature	Wird in der Veranstaltung bekannt gegeben.		

Courses					
Title	Тур	Hrs/wk	СР		
Nonlinear Dynamics (L0702)	Integrated Lecture	4	6		
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous	s • Calculus				
Knowledge					
	Linear Algebra Engineering Mechanics				
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 Nonlinear Dynamics and to develop and research new terms a				
	concepts.				
Skills	5 Students are able to apply existing methods and procesures of Nonlinear Dynamics and t	to develop novel meth	nods and procedure		
Personal Competence					
Social Competence	Students can reach working results also in groups.				
Autonomy	v 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	5 6				
Course achievement	t None				
Examination	N Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory				
Following Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Com	ipulsory			
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elect	tive Compulsory			
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsor	rу			
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective (Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Electiv	ve Compulsory			
	Product Development, Materials and Production: Core Qualification: Elective Compulsory				
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compuls	ory			
	Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory				

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

Courses				
Title		Tura	Hrs/wk	СР
Semiconductor Technology (L0722		Typ Lecture	4	4
Semiconductor Technology (L0723		Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science and se	miconductor devices		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
	Students are able			
	 to describe and to explain current fabrication tee 	chniques for SI and GaAs substrates,	,	
	• to discuss in details the relevant fabrication	on processes, process flows and t	the impact thereof o	n the fabrication
	semiconductor devices and integrated circuits and			
	 to present integrated process flows. 			
Skills				
	Students are capable			
	 to analyze the impact of process parameters on 	the processing results,		
	 to select and to evaluate processes and 			
	 to develop process flows for the fabrication of set 	miconductor dovicos		
		iniconductor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab e of audience.	experiments in team work as well as	s to present and discu	ss the results in fro
	or addience.			
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 8	4		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronic	s and Microsystems Technology: Ele	ective Compulsory	
•	Biomedical Engineering: Specialisation Artificial Orga			
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulso	ry	
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Management		ve Compulsory	
	Microelectronics and Microsystems: Core Qualificatio	n: Elective Compulsory		

 Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damag annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuu evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximil and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique ar electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electrr beam lithography, X-ray lithography, EUV lithography, ion beam lithography wet chemical etching: isotropic ar anisotropic, corner undercuting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchin backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) 	Course L0722: Semiconducto	or Technology
cp 4 Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Lecturer Piot. Noc Khiem Tireu Language DE/EM Cytel 555 Content Introduction (historical view and trends in microalectronics) Basics in material science (semiconductor, crystal, Miller Indices, crystallographic defects) Crystal fibrication (crystal pulling for 51 and Cask: impurities, purification, Czochraiski, Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implanation: theory, implantation profile, channeling, implantation damag annealing and equipment) Oxidation (allicon diaxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, knetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation Gask) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, incident dependence and equipment; galaxy, as phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition or metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques; high vacue vaporation, sputtering) Structuring techniques (subtractive methods, photolithography, resist properties, printing techniques: lindin drenique, anisotropi, correru	Тур	Lecture
Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Lecture? Prof. Hoc Kniem Trieu Language DE/N Cycle SoSe Content Introduction (historical view and trends in microelectronics) Crystal fabrication (crystal pulling for 51 and Gaaks: impurities, purification. (2xothalski), Bridgeman and float zone process) Crystal fabrication (crystal pulling for 51 and Gaaks: impurities, purification. (2xothalski), Bridgeman and float zone process) Water tabrication (crystal pulling for 51 and Gaaks: impurities, purification. (2xothalski), Bridgeman and float zone process) Water tabrication (crystal pulling for 51 and Gaaks: impurities, purification. (2xothalski), Bridgeman and float zone process) Water tabrication (crystal pulling for 51 and Gaaks) Opping (neergy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damag annealing and equipment; Oxidation (islicon dixide: structure, electrical properties and oxide charges, thermal oxidation, thermal oxidation Gaaka) Opposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; photolithography. resist properties, printing techniques: contact, proximil and projection printing, resolution itmin, practical issues and equipment, hadditive methods: liftoff techniques an anistotropic, concer undercruting, compestation masks and ect	Hrs/wk	4
Lacturer Prof. Hoc Khiem Trieu Language DE/RN Cyclet Sole Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Water fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damag annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation; reactions, kinetic influences on growth rate, process technology and equipment, andic oxidation, pisma oxidation, thermal oxidation GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PMD techniques: high vacuu evaporation, sputtering) Structuring techniques (subtractive methods, photolithography, resist properties, printing techniques: indivacuu evaporation, pautering) Structuring techniques (subtractive methods, photolithography, resist properties, printing techniques: indivacuu evaporation, pautering) Structuring techniques (subtractive methods, photolithography, wet chemical etching: isotoropic correr underocul	CP	4
Language DE/EN SoSe SoSe Content Introduction (historical view and trends in microelectronics). Badics in material science (semiconductor, crystal, Miller Indices, crystallographic defects). • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process). • Wafer fabrication (process flow, specification, SOI) • Tabrication processes • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theny, implantation profile, channeling, implantation damag annealing and equipment! • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation (SaAs) • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD technique APCVD, LPCVD, deposition of metal silicide, PCEVD and LECVD, basics of plasma, equipment; notoris: ling profile, high vacuu evaporation, sputtering) • Structuring techniques (tubory: nucleation link, proztical issues and explore techniques: cintact, proximi and projection printing, resolution link, proztical issue and equipment; additive methods: lintfort technique are aniostropic, come undercurfing, compensation masks and ecth spit techniques; diny etchnig: plasma enintotropic, norme unde	Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Cycle SoSe Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miler indices, crystallographic defects) Crystal fabrication (crysta pulling for Si and Galax: inpurtiles, purification, Czochraiski , Bridgeman and float zone process) Wafer fabrication (prospecting pulling for Si and Galax: inpurtiles, purification, Czochraiski , Bridgeman and float zone process) Crystal fabrication (prospecting) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation diavide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques APCVD, UEVO, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuu evaporation, sputtering) Structuring techniques (subtractive methods, photolithography resist properties, printing techniques: third technique an electroplating, improving resolution: exciner laser light source, immersion lindography and phase, where we chemical etchnic backsputtering, ion milling, chemical dry etching: plasma enhanced etchin backsputtering, ion milling, chemical dry etching, plasma massivation) Process integration (CMOS process), bipol	Lecturer	Prof. Hoc Khiem Trieu
Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (process faw, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damag annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation, treation, GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicie, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacua evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximit and projection printing, resolution limit, practical itsues and equipment, additive methods: liftoff technique are electroplating, iom villing, chemical dry etching, kets viewaporation) Structuring techniques (subtractive methods, photolithography, resist properties, printing techniques isotropic ar anisotropic, corner underculting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching backsputering, iom villing, chemical dry etching, RE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical con	Language	DE/EN
 Introduction (historical view and trends in microelectronics) Basics in material science (exemiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for 51 and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Vater fabrication (process flow, specification, 50) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damag annealing and equipment) Oxidiation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation, teractions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment: epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: injd vacuu evaporation, sputtering) Structuring techniques (ubbractive methods, photolithography: resist properties, printing techniques: contact, proximi and projection printing, resolution limit, practical issues and equipment, additive methods: liftogf technique ar anisotropic, corner undercuting, compensation masks and tech stop techniques; dry etching: plasma enhanced etchin backsputtering, ion milling, chemical dry etching, RE, idewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology. (Interarchy of integration, packages, chip-on-board, chip assembly, electrical contact wire bonding, TAB and flip chip, wafer level package, 3D stacking)	Cycle	SoSe
 S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press 	Content	 Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, highe order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation o GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution iexcimer laser light source, immersion lithography and phase shift lithography, electrica beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integrati
 U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press 	Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press		S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press		U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press		H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
		K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill		S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
		P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Course L0723: Semiconducto	ourse L0723: Semiconductor Technology	
Тур	Practical Course	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hoc Khiem Trieu	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module Manual M.Sc. "Biomedical Engineering"

Module M0835: Huma	anoid Robotics				
Courses					
Title		Тур	Hrs/wk	СР	
Humanoid Robotics (L0663)		Seminar	2	2	
Module Responsible	Patrick Göttsch				
Admission Requirements	None				
Recommended Previous					
Knowledge	 Introduction to control systems 				
	Control theory and design				
	Control theory and design				
Educational Objectives	After taking part successfully, students have read	ched the following learning results			
Professional Competence					
Knowledge	• Students can explain humanoid robots.				
	 Students can explain humanoid robots. Students learn to apply basic control conc 	ents for different tasks in humanoid r	obotics		
	• Students learn to apply basic control conc		obotics.		
Skills	 Students acquire knowledge about selected 	ad aspects of humanoid robotics base	d on specified literature		
	 Students dequire knowledge about selecte Students generalize developed results and 		a on specifica ficerature	•	
	 Students practice to prepare and give a pr 				
Personal Competence					
Social Competence	Students are capable of developing solutions in interdisciplinary teams and present them				
	• They are able to provide appropriate feed				
Autonomy	 Students evaluate advantages and draw 	backs of different forms of present	ation for specific tasks	and select the b	
	solution				
	• Students familiarize themselves with a so	cientific field, are able of introduce it	and follow presentatio	ns of other studer	
	such that a scientific discussion develops				
Weddeed in Herry	ladan and ant Chudu Tinan 22. Chudu Tinan in Lastu				
Workload in Hours		116 20			
Credit points					
Course achievement Examination	None Presentation				
Examination duration and scale	30 min				
	Machatronica, Enacialization Intelligent Systems	and Pohotics: Floctive Compulsary			
-	Mechatronics: Specialisation Intelligent Systems Mechatronics: Specialisation System Design: Elec				
i onowing curricula	Biomedical Engineering: Specialisation Artificial (ective Compulsory		
	Biomedical Engineering: Specialisation Implants				
	Biomedical Engineering: Specialisation Medical T				
	Biomedical Engineering: Specialisation Managem				
	Theoretical Mechanical Engineering: Technical Co				
	Theoretical Mechanical Engineering: Specialisation	on Bobotics and Computer Science, El	ective Compulsory		

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

Courses						
Title		Тур	Hrs/wk	СР		
Linear and Nonlinear System Ident	fication (L0660)	Lecture	2	3		
Module Responsible	Prof. Herbert Werner					
Admission Requirements	None					
Recommended Previous						
Knowledge	Classical control (frequency response, i	root locus)				
	State space methods					
	Discrete-time systems					
	Linear algebra, singular value decompo					
	Basic knowledge about stochastic proce	esses				
Educational Objectives	After taking part successfully, students have r	reached the following learning results				
Professional Competence						
Knowledge						
	Students can explain the general fram	nework of the prediction error method	and its application to a	variety of linear		
	nonlinear model structuresThey can explain how multilayer perceptron networks are used to model nonlinear dynamics					
			-			
	 They can explain how an approximate They can explain the idea of subgrass 			eis		
	• They can explain the idea of subspace		realisation theory			
Skills						
 Students are capable of applying the predicition error method to the experimental identification 						
	models for dynamic systems					
	They are capable of implementing a no					
	 They are capable of applying subspace They can do the above using standard 					
	• They can do the above using standard	software tools (including the Matlab Sys		JX)		
Personal Competence						
Social Competence	Students can work in mixed groups on specifi	c problems to arrive at joint solutions.				
Autonomu	Students are able to find required informatior	in courses provided (lecture potes, lite	vratura, coftwara documo	ontation) and use		
Autonomy	solve given problems.	i in sources provided (lecture notes, lite	acure, soltware docume	and use		
	solve given problems.					
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28				
Credit points	3					
Course achievement	None					
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Electrical Engineering: Specialisation Control	and Power Systems Engineering: Electiv	e Compulsory			
Following Curricula	Mechatronics: Specialisation Intelligent Syster	ms and Robotics: Elective Compulsory				
-	Mechatronics: Specialisation System Design: I	Elective Compulsory				
	Biomedical Engineering: Specialisation Artifici	al Organs and Regenerative Medicine: I	Elective Compulsory			
	Biomedical Engineering: Specialisation Implar	its and Endoprostheses: Elective Compu	ulsory			
	Biomedical Engineering: Specialisation Medica	al Technology and Control Theory: Com	oulsory			
	Biomedical Engineering: Specialisation Manag	ement and Business Administration: Ele	ective Compulsory			
	Theoretical Mechanical Engineering: Technica	I Complementary Course: Elective Com	pulsory			
	Theoretical Mechanical Engineering: Core Qua	alification: Elective Compulsory				

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

Courses					
Title Optimal and Robust Control (L0658		Typ Lecture	Hrs/wk 2	СР 3	
Optimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible					
Admission Requirements					
Recommended Previous					
Knowledge	 Classical control (frequency response, root locus) 				
	State space methods				
	Linear algebra, singular value decomposition				
Educational Objectives	After taking part successfully, students have reached th	e following learning results			
Professional Competence					
Knowledge					
	 Students can explain the significance of the matr 				
	 They can explain the duality between optimal sta 	1			
	• They can explain how the H2 and H-infinity norm				
	They can explain how an LQG design problem can		5 1		
	They can explain how model uncertainty can be They can explain how bacad on the small gain			-	
	 They can explain how - based on the small gain an uncertain plant. 	theorem - a robust controller can gu	arantee stability	and performance	
	 They understand how analysis and synthesis con 	ditions on feedback loops can be repr	esented as linear	matrix inequaliti	
	• They understand now analysis and synthesis con		conteu us inteur	matrix mequanti	
Skills	 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 				
	software tools for solving it.				
	 They are capable of translating time and freque 	ncy domain specifications for control	loops into const	raints on closed-	
	sensitivity functions, and of carrying out a mixed-sensitivity design.				
	• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objection				
	robust controller.				
	They are capable of formulating analysis and syn	thesis conditions as linear matrix ine	qualities (LMI), a	nd of using stand	
	LMI-solvers for solving them.				
	 They can carry out all of the above using standar 	d software tools (Matlab robust contro	l toolbox).		
Personal Competence					
	Students can work in small groups on specific problems	to arrive at joint solutions			
	Students are able to find required information in source		oftware docume	ntation) and use	
raconomy	solve given problems.			indución, una use	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	None				
Examination	Oral exam				
Examination duration and					
scale					
•	Electrical Engineering: Specialisation Control and Power		ulsory		
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems and Ro Mechatronics: Specialisation Intelligent Systems and Ro				
	Mechatronics: Specialisation Intelligent Systems and Ro Mechatronics: Specialisation System Design: Elective Co				
	Biomedical Engineering: Specialisation Artificial Organs		Compulson		
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En	-	2011puisory		
	Biomedical Engineering: Specialisation Medical Technolo		oulsorv		
	Biomedical Engineering: Specialisation Medical Fermion Biomedical Engineering: Specialisation Management and		-		
	Product Development, Materials and Production: Specia				
	Product Development, Materials and Production: Specia				
	Product Development, Materials and Production: Specia		-		
	Theoretical Mechanical Engineering: Technical Complen				
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory			

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

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

Courses		
Fitle	Typ Hrs/wk	СР
Marketing of Innovations (L2009)	Lecture 4	4
PBL Marketing of Innovations (L086		2
Module Responsible	Prof. Christian Lüthje	
Admission Requirements	None	
Recommended Previous		
Knowledge		
	 Basic understanding of business administration principles (strategic planning, decision theory, pro international business) 	ject managem
	 Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Basics of 	Buving Behavio
	Unerstanding the differences beweetn B2B and B2C marketing	., .
	Understanding of the importance of managing innovation in global industrial markets	
	Good English proficiency; presentation skills	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge		
	 Specific characteristics in the marketing of innovative poroducts and services 	
	 Approaches for analyzing the current market situation and the future market development 	
	The gathering of information about future customer needs and requirements	
	Concepts and approaches to integrate lead users and their needs into product and service development p	processes
	Approaches and tools for ensuring customer-orientation in the development of new products and innovation	ive services
	Marketing mix elements that take into consideration the specific requirements and challenges of innov	ative products
	services	
	 Pricing methods for new products and services The organization of complex sales forces and personal selling 	
	 Communication concepts and instruments for new products and services 	
Chille		
SKIIIS	Based on the acquired knowledge students will be able to:	
	 Design and to evaluate decisions regarding marketing and innovation strategies Analyze markets by applying market and technology portfolios 	
	 Conduct forecasts and develop compelling scenarios as a basis for strategic planning 	
	 Translate customer needs into concepts, prototypes and marketable offers and successfully apply adva 	anced methods
	customer-oriented product and service development	
	Use adequate methods to foster efficient diffusion of innovative products and services	
	Choose suitable pricing strategies and communication activities for innovations	
	Make strategic sales decisions for products and services (i.e. selection of sales channels)	
	Apply methods of sales force management (i.e. customer value analysis)	
Personal Competence		
Social Competence	The students will be able to	
	have fruitful discussions and exchange arguments	
	develop original results in a group	
	present results in a clear and concise way	
	carry out respectful team work	
Autonomy	The students will be able to	
	Acquire knowledge independently in the specific context and to map this knowledge on other new complete	ex problem field
	Consider proposed business actions in the field of marketing and reflect on them.	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70	
Credit points		
Course achievement	None	
Examination	Subject theoretical and practical work	
Examination duration and	Written elaboration, excercises, presentation, oral participation	
scale		
-	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory	
Following Curricula	International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: 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 Management and Business Administration: Compulsory	

Course L2009: Marketing of	Innovations
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
	Prof. Christian Lüthje
Language	
Cycle Content	I. Introduction
	 Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

Course L0862: PBL Marketing	g of Innovations
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1) forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation, managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making wtihin a market simulation game.
Literature	

Courses				
Title		Тур	Hrs/wk	СР
	ntals (10841)	Lecture	2	3
Bioprocess Engineering - Fundamentals (L0841) Bioprocess Engineering- Fundamentals (L0842)		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements				
Recommended Previous		e "fundamentals for process engineering"		
Knowledge	none, module organic chemistry , modul	e fundamentais for process engineering		
	After taking part successfully, students be	we reached the following learning results		
Educational Objectives Professional Competence	After taking part successfully, students ha	ive reached the following learning results		
Knowledge	enzymes and microorganisms, as well a rheology can be named and mass trans	oncepts of bioprocess engineering. They are able as to differentiate different types of inhibition. sport processes in bioreactors can be explained rrilization technology and downstream processing	The parameters of . The students ar	of stoichiometry a
Skills	 predict qualitatively the influence fermentation process analyze bioprocesses on basis of st distinguish between scale-up criter to compare them as well as to appl propose solutions to complicated b to explore new knowledge resource identify scientific problems with complementation 	e, students should be able to es for growth and substrate-uptake and to calcular of energy generation, regeneration of redox eq oichiometry and to set up / solve metabolic flux er ia for different bioreactors and bioprocesses (anar y them to current biotechnical problem iotechnological problems and to deduce the corres es and to apply the newly gained contents ncrete industrial use and to formulate solutions. edures as well as results in a scientific manner	uivalents and gro quations erobic, aerobic as	wth inhibition on t
Personal Competence Social Competence Autonomy	take position to their own opinions and inc	nts should be able to debate technical questions i crease their capacity for teamwork in engineering nts will be able to solve a technical problem in a plenum.	and scientific envi	ronments.
Werkland in Hours	Independent Study Time OF Study Time i	n Lactura 94		
	Independent Study Time 96, Study Time i			
Credit points		Description		
Course achievement	Yes 5% Subject theoreti			
	practical work			
Examination				
Examination duration and				
Examination duration and scale	90 min			
Assignment for the	General Engineering Science (German pro	gram, 7 semester): Specialisation Process Engine	ering: Compulsory	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory			
	Bioprocess Engineering: Core Qualification	n: Compulsory		
	General Engineering Science (English pro	gram, 7 semester): Specialisation Bioprocess Engi	neering: Compulso	ry
	General Engineering Science (English pro	gram, 7 semester): Specialisation Process Enginee	ring: Compulsory	
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Compu	lsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective Con	mpulsory	
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration: Elective	Compulsory	
	Technomathematics: Specialisation III. En	gineering Science: Elective Compulsory		
	Process Engineering: Core Qualification: C	ompulsory		

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	 Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) Kinetic of subtrate consumption and product formation (Prof. Zeng) Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) Transport process in a bioreactor (Prof. Zeng) Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	 K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess Engineering- Fundamentals		
Тур	Recitation Section (large)	
Hrs/wk	2	
СР	1	
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng	
Language	DE	
Cycle	SoSe	
Content	1. Introduction (Prof. Liese, Prof. Zeng)	
	2. Enzymatic kinetics (Prof. Liese)	
	3. Stoichiometry I + II (Prof. Liese)	
	4. Microbial Kinetics I+II (Prof. Zeng)	
	5. Rheology (Prof. Liese)	
	6. Mass transfer in bioprocess (Prof. Zeng)	
	7. Continuous culture (Chemostat) (Prof. Zeng)	
	8. Sterilisation (Prof. Zeng)	
	9. Downstream processing (Prof. Liese)	
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)	
Literature	siehe Vorlesung	

Course L0843: Bioprocess En	ngineering - Fundamental Practical Course
Тур	Practical Course
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Me	chatronics (L1523)	Lecture	2	2
Applied Design Methodology in Me	chatronics (L1524)	Project-/problem-based Learnir	ig 3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous	Basics of mechanical design, electrical design	sign or computer-sciences		
Knowledge				
Educational Objectives	After taking part successfully, students ha	we reached the following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinar	y product design considering targeted application of	specific product	design technique
CL 111-				
SKIIIS	÷ ,	cientific preparation and formulation of complex pro	auct design prot	piems / Applicatio
	various product design techniques following	ng theoretical aspects.		
Personal Competence				
Social Competence	Students will solve and execute technica	al-scientific tasks from an industrial context in sm	all design-team	s with applicatio
	common, creative methodologies.			
Autonomy	Students are enabled to optimize the desi	gn and development process according to the targe	t and topic of the	e design
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70		
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	30 min Presentation for a group design-we	ork		
scale				
Assignment for the	International Management and Engineerin	g: Specialisation II. Product Development and Produ	ction: Elective C	ompulsory
Following Curricula	International Management and Engineerin	g: Specialisation II. Mechatronics: Elective Compulse	ory	
	Mechanical Engineering and Management	: Specialisation Product Development and Productio	n: Elective Comp	oulsory
	Mechatronics: Specialisation System Desig	gn: Elective Compulsory		
	Biomedical Engineering: Specialisation Art	tificial Organs and Regenerative Medicine: Elective C	Compulsory	
		plants and Endoprostheses: Elective Compulsory		
	• • •	edical Technology and Control Theory: Elective Comp	-	
		anagement and Business Administration: Elective Co		
	• • •	ialisation Product Development and Production: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory		

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	 Systematic analysis and planning of the design process for products combining a multitude of disciplines Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics) Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,) Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making Value-analysis Derivation of architectures and architectural management Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) Presentation-skills Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) Evaluation of selected methods at practical examples in small teams
Literature	 Definition folgt Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoder und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff

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

Courses				
Title	Туј	p	Hrs/wk	СР
Introduction to Physiology (L0385)	Lec	ture	2	3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following le	earning results		
Professional Competence				
Knowledge	The students can			
	 describe the basics of the energy metabolism; 			
	 describe physiological relations in selected fields of muscle, he 	eart/circulation. neu	ro- and sensory physic	ology.
Skills	The students can describe the effects of basic bodily functions (sens		nd processing of inforr	nation, developm
	of forces and vital functions) and relate them to similar technical sys	tems.		
Personal Competence				
Social Competence	The students can conduct discussions in research and medicine on a			
	The students can find solutions to problems in the field of physiology	, both analytical and	d metrological.	
Autonomy	The students can derive answers to questions arising in the course	e and other physiol	ogical areas, using tee	chnical literature,
	themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): Special	lisation Biomedical I	Engineering: Compulso	ory
Following Curricula	General Engineering Science (German program, 7 semester): S	pecialisation Mech	anical Engineering, F	ocus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory			
	Electrical Engineering: Specialisation Medical Technology: Elective Co	ompulsory		
	Engineering Science: Specialisation Biomedical Engineering: Elective			
	General Engineering Science (English program, 7 semester): S	pecialisation Mecha	anical Engineering, F	ocus Biomechani
	Compulsory	cation Diamodical E	nainaaring, Compulso	. .
	General Engineering Science (English program, 7 semester): Speciali			
	General Engineering Science (English program, 7 semester): Speciali Mechanical Engineering: Specialisation Biomechanics: Compulsory	Sation Diometrical E	ingineering. Elective Cl	ларизоту
	Biomedical Engineering: Specialisation Biomedical Technology and Cont	rol Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Management and Business Ac			
	Biomedical Engineering: Specialisation Artificial Organs and Regener			
	Biomedical Engineering: Specialisation Implants and Endoprostheses			
	Technomathematics: Specialisation III. Engineering Science: Elective	•	-	

Course L0385: Introduction t	o Physiology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Gerhard Engler
Language	DE
Cycle	SoSe
Content	
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier

_				
Courses				
Title Introduction to Anatomy (L0384)		Typ Lecture	Hrs/wk	СР 3
Module Responsible	Prof IIdo Schumacher	Lecture	L	5
Admission Requirements	None			
Recommended Previous	None			
Knowledge	None			
5	After taking part successfully, students have reacl	ned the following learning results		
Professional Competence	······ ·······························	····· ································		
•	The students can describe basal structures and fu The students can describe the basic macroscopy a	-	nusculoskeletal system.	
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; t can explain the relevance of structures and their functions in the context of widespread diseases.			
Personal Competence				
Social Competence	The students can participate in current discussion	s in biomedical research and medio	cine on a professional leve	l.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acc the relevant knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture	e 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7	semester): Specialisation Biomedia	cal Engineering: Compulso	ry
Following Curricula	General Engineering Science (German program	n, 7 semester): Specialisation M	echanical Engineering, F	ocus Biomechan
	Compulsory			
	Data Science: Specialisation Medicine: Compulsor	¢		
	Electrical Engineering: Specialisation Medical Tech	nology: Elective Compulsory		
	Engineering Science: Specialisation Biomedical En	5 5 1 5		
	General Engineering Science (English program	, 7 semester): Specialisation Me	echanical Engineering, F	ocus Biomechan
	Compulsory			
	General Engineering Science (English program, 7			
	General Engineering Science (English program, 7 -		ai Engineering: Compulsor	У
	Mechanical Engineering: Specialisation Biomechar			
	Biomedical Engineering: Specialisation Medical Te Biomedical Engineering: Specialisation Manageme			
	Biomedical Engineering: Specialisation Manageme Biomedical Engineering: Specialisation Artificial O			
	Biomedical Engineering: Specialisation Implants a			

Course L0384: Introduction t	o Anatomy	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study	/ Time 62, Study Time in Lecture 28
	Prof. Tobias Lange	
Language		
Cycle		
Content	General Anatom	V .
	1 st week:	The Eucaryote Cell
	2 nd week:	The Tissues
	3 rd week:	Cell Cycle, Basics in Development
	4 th week:	Musculoskeletal System
	5 th week:	Cardiovascular System
	6 th week:	Respiratory System
	7 th week:	Genito-urinary System
	8 th week:	Immune system
	9 th week:	Digestive System I
	10 th week:	Digestive System II
	11 th week:	Endocrine System
	12 th week:	Nervous System
	13 th week:	Exam
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implanta	te und Frakturheilung" before attending	"Experimentelle Methode	n".
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways	how bones heal, and the requirements f	or their existence.	
	The students can name different treatments	or the spine and hollow bones under giv	en fracture morphologies	
	The students can describe different measure	ment techniques for forces and moveme	nts, and choose the adeq	uate technique for
	given task.	·		
Skills	The students can describe the basic handling	of several experimental techniques used	d in biomechanics.	
Personal Competence				
Social Competence	The students can, in groups, solve basic expe	rimental tasks.		
Autonomy	The students can, in groups, solve basic expe	rimental tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Le	ecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German pro	gram, 7 semester): Specialisation Me	chanical Engineering, F	ocus Biomechanic
Following Curricula	Compulsory			
	General Engineering Science (German progra		al Engineering: Compulso	ry
	Engineering Science: Specialisation Biomedic			
	General Engineering Science (English pro	gram, 7 semester): Specialisation Me	chanical Engineering, Fo	ocus Biomechanic
	Compulsory			
	General Engineering Science (English program			•
	General Engineering Science (English program		il Engineering: Elective Co	mpulsory
	Mechanical Engineering: Specialisation Biome		lective Compulson	
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla			
	Biomedical Engineering: Specialisation Implat Biomedical Engineering: Specialisation Medic		•	
	Biomedical Engineering: Specialisation Medic			
	Technomathematics: Specialisation III. Engine		cure compulsory	

Course L0377: Experimental	se L0377: Experimental Methods in Biomechanics		
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		
Cycle	SoSe		
Content			
Literature	Wird in der Veranstaltung bekannt gegeben		

ourses				
itle		Тур	Hrs/wk	СР
ntroduction to Radiology and Radi	ation Therapy (L0383)	Lecture	2	3
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Professional Competence	After taking part successfully, students have r	eached the following learning results		
Knowledge	Therapy			
	The students can distinguish different types o	f currently used equipment with respect	to its use in radiation the	erapy.
	The students can explain treatment plans use	d in radiation therapy in interdisciplinary	/ contexts (e.g. surgery,	nternal medicine
	The students can describe the patients'	bassage from their initial admittanc	e through to follow-up	care.
	Diagnostics			
	The students can illustrate the technical base well as sectional imaging techniques (CT, MRT		cluding angiography and	d mammography,
	The students can explain the diagnostic as w techniques.	ell as therapeutic use of imaging techni	ques, as well as the tech	inical basis for the
	The students can choose the right treatment r	nethod depending on the patient's clinic	al history and needs.	
	The student can explain the influence of tech	nical errors on the imaging techniques.		
	The student can draw the right conclusions ba	sed on the images' diagnostic findings o	or the error protocol.	
Skille	Therapy			
SKIIIS	The students can distinguish curative and pall	iative situations and motivate why they	came to that conclusion.	
	The students can develop adequate therapy c		nogical aspects.	
	The students can use the therapeutic principle	e (effects vs adverse effects)		
	The students can distinguish different kinds tumor) and choose the energy needed in that		depending on the situa	tion (location of
	The student can assess what an individual groups, self-help groups, social services, psyc		e.g. follow-up treatment	, sports, social h
	Diagnostics			
	The students can suggest solutions for repairs	of imaging instrumentation after having	g done error analyses.	
	The students can classify results of imaging anatomy, pathology and pathophysiology.	techniques according to different grou	ps of diseases based or	n their knowledge
Personal Competence				
Social Competence	The students can assess the special social situ The students are aware of the special, ofte measures and can meet them appropriately.			
Autonomy	The students can apply their new knowledge a The students can introduce younger students			
	The students are able to access anatomical k and acquire the relevant knowledge themselv	• • • • •	te competently in conve	rsations on the to
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale Assignment for the	General Engineering Science (German progra	n 7 semester): Specialisation Riomodics	al Engineering: Computer	ITV.
-	General Engineering Science (German prograt General Engineering Science (German prog	•		-
	Compulsory		5 5 / -	
	Data Science: Specialisation Medicine: Compu			
	Electrical Engineering: Specialisation Medical			
	Engineering Science: Specialisation Biomedica General Engineering Science (English prog		chanical Engineering F	ocus Biomechan
	Compulsory		,	

Module Manual M.Sc. "Biomedical Engineering"

General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introduction t	to Radiology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Cycle	
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments
Literature	 "Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999
	• "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –
	4. Auflage - Verlag Urban & Fischer – erschienen 02.03.2006
	ISBN: 978-3-437-23960-1
	"Strahlentherapie und Onkologie für MTA-R" von R. Sauer –
	5. Auflage 2003 - Verlag Urban & Schwarzenberg – erschienen 08.12.2009
	ISBN: 978-3-437-47501-6
	"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus-
	8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012
	ISBN: 978-3-13-567708-8
	• "Der Körper des Menschen " von A. Faller u. M. Schünke -
	16. Auflage 2004 – Georg Thieme Verlag – erschienen 18.07.2012
	ISBN: 978-3-13-329716-5
	"Praxismanual Strahlentherapie" von Stöver / Feyer –
	1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000

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Courses				
Title		Typ Lecture	Hrs/wk	CP 3
Artificial Joint Replacement (L1306)		Lecture	Z	3
Module Responsible				
Admission Requirements				
	Basic knowledge of orthopedic and surgic	al techniques is recommended.		
Knowledge				
	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students can name the different kind	s of artificial limbs.		
Skills	The students can explain the advantages	and disadvantages of different kinds of end	loprotheses.	
Personal Competence				
Social Competence	The students are able to discuss issues re	elated to endoprothese with student mates a	and the teachers.	
Autonomv	The students are able to acquire informat	ion on their own. They can also judge the ir	nformation with respect to	its credibility.
			•	,
Workload in Hours	Independent Study Time 62, Study Time i	n Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering	ng: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano an	d Hybrid Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Im			
		edical Technology and Control Theory: Elect		
		anagement and Business Administration: El	ective Compulsory	
	Orientierungsstudium: Core Qualification:			
		nical Complementary Course: Elective Com cialisation Bio- and Medical Technology: Elec		

Course L1306: Artificial Joint	Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)
Literature	Literatur:
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.
	Sobotta und Netter für Anatomie der Gelenke

Courses				
Title Feedback Control in Medical Techn		Typ Lecture	Hrs/wk	СР 3
Module Responsible		Lecture	2	5
Admission Requirements				
	Basics in Control, Basics in Physiology			
Knowledge				
5	After taking part successfully, students h	nave reached the following learning results		
Professional Competence		5 5		
Knowledge	The lecture will introduce into the fasc	inating area of medical technology with the	engineering point of vi	ew. Fundamentals
	human physiology will be similarly introduced like knowledge in control theory.			
	Internal control loops of the human he	dy will be discussed in the same way like t	he decign of external of	lacad laan system
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system example in for anesthesia control.			
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will I			
	illustrated. The operation of simple equivalent circuits will be discussed.			
Skills	kills Application of modeling, identification, control technology in the field of medical technology.			
01110				
Personal Competence				
	Students can develop solutions to specif	ic problems in small groups and present their	results	
Autonomy	v Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate			
	their knowledge and to take control of their learning process. They can combine knowledge from different courses to form			
	consistent whole.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Me	dical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory	
	Biomedical Engineering: Specialisation In	mplants and Endoprostheses: Elective Compu	lsory	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: E	lective Compulsory	
	Biomedical Engineering: Specialisation N	lanagement and Business Administration: Ele	ctive Compulsory	
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Comp	ulsory	

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

Courses				
Fitle		Тур	Hrs/wk	СР
Advanced Topics in Control (L0661)		Lecture	2	3
Advanced Topics in Control (L0662)		Recitation Section (small)	2	3
Module Responsible				
-				
Admission Requirements				
	H-infinity optimal control, mixed-sensitivity design, lin	ear matrix inequalities		
Knowledge				
	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	 Students can explain the advantages and short They can explain the representation of nonlinea They can explain how stability and performance They can explain how gridding techniques can They are familiar with polytopic and LFT rep associated with each of these model structures 	ar systems in the form of quasi-LPV syst e conditions for LPV systems can be for be used to solve analysis and synthesis presentations of LPV systems and som	ems mulated as LMI cc problems for LPV ne of the basic s	/ systems synthesis techniqu
	 Students can explain how graph theoretic consystems They can explain the convergence properties o They can explain analysis and synthesis conditional synthesis conditional	f first order consensus protocols	·	
	 Students can explain the state space represent to an actuator/sensor array They can explain (in outline) the extension o synthesis conditions for distributed controllers 			
Skills	 Students are capable of constructing LPV more scheduled controllers; they can do this using portion. They are able to use standard software tools (Merece) Students are able to design distributed formation Matlab tools provided 	olytopic, LFT or general LPV models Aatlab robust control toolbox) for these f	tasks	
	 Students are able to design distributed controll Students can work in small groups and arrive at joint in Students are able to find required information in source solve given problems. 	results.		
	Independent Study Time 124, Study Time in Lecture 5	36		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
	Electrical Engineering: Specialisation Control and Pow	er Systems Engineering: Elective Comp	ulsory	
Assignment for the				
-				
-	Aircraft Systems Engineering: Specialisation Aircraft S			
-	Aircraft Systems Engineering: Specialisation Aircraft S	tive Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect		00/	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialis	ation II. Mechatronics: Elective Compuls	ory	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective	ation II. Mechatronics: Elective Compuls Compulsory	ory	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective Mechatronics: Specialisation Intelligent Systems and F	ation II. Mechatronics: Elective Compuls Compulsory Robotics: Elective Compulsory	ory	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective Mechatronics: Specialisation Intelligent Systems and F Biomedical Engineering: Specialisation Implants and E	ation II. Mechatronics: Elective Compuls Compulsory Robotics: Elective Compulsory Endoprostheses: Elective Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective Mechatronics: Specialisation Intelligent Systems and F Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Medical Techn	ation II. Mechatronics: Elective Compuls Compulsory Robotics: Elective Compulsory Endoprostheses: Elective Compulsory ology and Control Theory: Elective Com	pulsory	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective Mechatronics: Specialisation Intelligent Systems and F Biomedical Engineering: Specialisation Implants and E	ation II. Mechatronics: Elective Compuls Compulsory Robotics: Elective Compulsory Endoprostheses: Elective Compulsory ology and Control Theory: Elective Com	pulsory	
-	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Core Qualification: Elect International Management and Engineering: Specialisa Mechatronics: Specialisation System Design: Elective Mechatronics: Specialisation Intelligent Systems and F Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Medical Techn	ation II. Mechatronics: Elective Compuls Compulsory Robotics: Elective Compulsory Endoprostheses: Elective Compulsory ology and Control Theory: Elective Com and Business Administration: Elective Co	pulsory	

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

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

Courses							
Title			Тур	Hrs/wk	СР		
Bioelectromagnetics: Principles and Bioelectromagnetics: Principles and			Lecture Recitation Section (small)	3 2	5 1		
			Recitation Section (smail)	Z	T		
•	Prof. Christian Schuster						
Admission Requirements							
	Basic principles of physics						
Knowledge							
Educational Objectives	After taking part successfully, stude	ts have reached the follow	ing loorning results				
Professional Competence	After taking part successfully, stude		ing learning results				
•	Students can explain the basic princ	nles relationships and me	thods of bioelectromagnetics	i e the quantific	ation and applicati		
Knowledge	of electromagnetic fields in biologic		-				
	them corresponding to wavelength						
	techniques for characterization of e						
	diagnostic utilization of electromagn	5					
Skills	Students know how to apply various	methods to characterize th	e behavior of electromagnetion	fields in biologic	al tissue. In order		
	do this they can relate to and mak	e use of the elementary so	olutions of Maxwell's Equation	ns. They are able	e to assess the mo		
	important effects that these model	s predict for biological tiss	sue, they can order the effect	cts corresponding	, to wavelength a		
	frequency, respectively, and they ca	n analyze them in a quant	itative way. They are able to	develop validatio	n strategies for the		
	predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make a						
	appropriate choice.						
Personal Competence							
Social Competence	Students are able to work together	•	n small groups. They are able	to present their	results effectively		
	English (e.g. during small group exe	cises).					
4	Chudanta and annalis to anthen int				. :		
Αυτοποτηγ	context of the lecture. They are abl				and relate that information to the		
	-		5				
	other lectures (e.g. theory of elect problems and effects in the field of the	-	-	ig / physics). The			
	problems and enects in the field of t		1511.				
Workload in Hours	Independent Study Time 110, Study	Time in Lecture 70					
Credit points							
Course achievement	Compulsory Bonus Form	Description					
	Yes None Presentation						
Examination	Oral exam						
Examination duration and	45 min						
scale							
Assignment for the	Electrical Engineering: Specialisatior	Microwave Engineering O	ptics, and Electromagnetic Co	mpatibility: Electi	ive Compulsory		
-							
	International Management and Engin			Compulsorv			
	Biomedical Engineering: Specialisati	• •					
	Biomedical Engineering: Specialisati						
	Biomedical Engineering: Specialisati	-					
	Biomedical Engineering: Specialisati			-			
			dical Technology: Elective Con	anulcon			

Тур	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	
Cycle	WiSe
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Course L0373: Bioelectromag	rse L0373: Bioelectromagnetics: Principles and Applications		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Christian Schuster		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Specialization Artificial Organs and Regenerative Medicine

Module M0623: Intell	igent Systems	n Medicine			
Courses					
Title			Тур	Hrs/wk	СР
ntelligent Systems in Medicine (L0	331)		Lecture	2	3
ntelligent Systems in Medicine (L0			Project Seminar	2	2
ntelligent Systems in Medicine (L0			Recitation Section (small)	1	1
Module Responsible		efer			
Admission Requirements	None				
Recommended Previous	 principles of m 	ath (algebra, analysis/calcu	ulus)		
Knowledge	 principles of st 				
	 principles of pr 	ogramming, Java/C++ and	l R/Matlab		
	 advanced prog 	ramming skills			
Educational Objectives	After taking part succ	essfully, students have rea	ached the following learning results		
Professional Competence		-	- *		
Knowledge	The students are abl	e to analyze and solve clin	ical treatment planning and decision supp	ort problems using	g methods for searc
	optimization, and pla	nning. They are able to exp	plain methods for classification and their re	espective advantag	es and disadvantage
	in clinical contexts. T	ne students can compare	different methods for representing medical	knowledge. They o	can evaluate method
	in the context of clin	cal data and explain chall	lenges due to the clinical nature of the da	ta and its acquisitio	on and due to priva
	and safety requireme	nts.			
Skills	The students can giv	e reasons for selecting an	d adapting methods for classification, reg	ession, and predic	tion. They can asse
	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can asse the methods based on actual patient data and evaluate the implemented methods.				
Personal Competence					
	The students discuss	the results of other groups	, provide helpful feedback and can incoorp	orate feedback into	o their work.
			, F		
Autonomy	The students can ref	ect their knowledge and d	locument the results of their work. They c	an present the res	ults in an appropriat
	manner.				
Workload in Hours	Independent Study Ti	me 110, Study Time in Lec	ture 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination					
Examination duration and	90 minutes				
scale					
-	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory				
Following Curricula			chnology: Elective Compulsory		
			and Robotics: Elective Compulsory		
	-	•	Organs and Regenerative Medicine: Electiv	e Compulsory	
	-	• •	and Endoprostheses: Elective Compulsory		
	-	•	Technology and Control Theory: Elective Co		
	-	• • •	nent and Business Administration: Elective		
		5 5	Complementary Course: Elective Compulso	,	
	Ineoretical Mechanic	aı Engineering: Specialisati	ion Bio- and Medical Technology: Elective C	ompulsory	

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

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

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

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	63)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic		Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and B	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
· · · · · · · · · · · · · · · · · · ·	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Co	mpulsory	

Course L1663: Nature's Hiera	archical Materials
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc.This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
-	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - 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 - Most important types of antenna and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering
Literature	 Standards and regulations EMC measurement techniques Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) D. M. Pozar, "Microwave Engineering", Wiley (2011) Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Implants	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

Course L1890: Seminar Biomedical Engineering	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

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

ourse L0001: Fluid Mechani	Lecture
Тур	
Hrs/wk	
СР	
Workload in Hours	
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	
Language	
Cycle	WiSe
Content	Differential equations for momentum-, heat and mass transfer
	 Examples for simplifications of the Navier-Stokes Equations
	Unsteady momentum transfer
	Free shear layer, turbulence and free jets
	 Flow around particles - Solids Process Engineering
	Coupling of momentum and heat transfer - Thermal Process Engineering
	Rheology – Bioprocess Engineering
	 Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering
	 Flow threw porous structures - heterogeneous catalysis
	 Pumps and turbines - Energy- and Environmental Process Engineering
	Wind- and Wave-Turbines - Renewable Energy
	Introduction into Computational Fluid Dynamics
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.
	 Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	 Brudel, H., Newes, D.: Standastadischenschiererererenscher Reaktion. Franklart. Sadehander 1972. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.
	 Crowc, e. H. Engineering nationering in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg
	2006.
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	 Fox, R.W., et al. infoduction to Full Mechanics. J. Wiey & Sons, 1994. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunger
	Springer Verlag, Berlin, Heidelberg, New York, 2006.
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW Fachverlage GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner GWV Fachverlage GmbH, Wiesbaden, 2009.
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.
	 Schade, H., Kurz, E., Schnungsleine, Venag de Gruyter, Bernin, New York, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe
	Verlag, Berlin, Heidelberg, 2008.
	12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Course L1820: System Simulation	
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simulation	
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0379: Ceramics Tech	nnology		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Rolf Janßen		
Language			
Cycle	WiSe		
Content	based processing, e.g. "powder and cement science as well as	sing with emphasis on advanced structural ceramics. The course focus predominatly on powder- metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass new developments in powderless forming techniques of ceramics and ceramic composites will be iscussed in order to give engineering students an understanding of technology development and components. 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques	
Literature	ASM Engineering Materials Hand	Ceramics", John Wiley & Sons, New York, 1975 dbook Vol.4 "Ceramics and Glasses", 1991 nic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

Courses					
Title		Тур	Hrs/wk	СР	
Intelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4	
Intelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2	
Module Responsible	Rainer Marrone				
Admission Requirements	None				
	Vectors, matrices, Calculus				
Knowledge					
	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge		scribe the main features of environments. The ems and algorithms for solving these probler	notion of adversar	ial agent cooperat	
		w Bayesian networks can be employed as a k	-	-	
	formalism in static and dynamic settings. In	addition, students can define decision maki	ng procedures in s	imple and sequen	
	settings, with and with complete access to	the state of the environment. In this contex	t, students can de	scribe techniques	
	solving (partially observable) Markov decision	on problems, and they can recall techniques	for measuring the	value of informati	
		aneous localization and mapping, and can ex			
	desired states. Students can explain coordina of equilibria, social choice functions, voting p	ation problems and decision making in a mult rotocol, and mechanism design techniques.	i-agent setting in te	erm of different ty	
Skills	Students can select an appropriate agent a	rchitecture for concrete agent application sce	enarios. For simplif	ied agent applicat	
Sitilio	students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesia				
	networks/dynamic Bayesian networks and	apply bayesian reasoning for simple querie	s. Students can a	lso name and ap	
	different sampling techniques for simplified	agent scenarios. For simple and complex dec	ision making stude	ents can compute	
	best action or policies for concrete settings.	In multi-agent situations students will apply t	echniques for findi	ng different equili	
		lecision making students will apply different vo	oting protocols and	compare and exp	
	the results.				
Personal Competence					
Social Competence	Students are able to discuss their solutions to	problems with others. They communicate in	English		
Autonomy	Students are able of checking their understan	nding of complex concepts by solving varaints	of concrete proble	ms	
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale					
-	Computer Science: Specialisation II: Intelligen				
Following Curricula	International Management and Engineering:		tive Compulsory		
	Mechatronics: Technical Complementary Cou Mechatronics: Specialisation Intelligent Syste				
		ial Organs and Regenerative Medicine: Electiv	e Compulsory		
		nts and Endoprostheses: Elective Compulsory	2.50000000		
		al Technology and Control Theory: Elective Co	mpulsory		
	Biomedical Engineering: Specialisation Mana	gement and Business Administration: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulsor	У		
		sation Robotics and Computer Science: Electiv			
	Theoretical Mechanical Engineering: Specialis	sation Numerics and Computer Science: Election	ve Compulsory		

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

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

Module M0746: Micro	system Engine	ering				
Courses						
Title				Тур	Hrs/wk	СР
Microsystem Engineering (L0680)				Lecture	2	4
Microsystem Engineering (L0682)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper					
Admission Requirements	None					
Recommended Previous	Basic courses in phys	ics, mathematics	and electric engineering			
Knowledge						
Educational Objectives	After taking part succ	essfully, students	s have reached the follow	ing learning results		
Professional Competence						
Knowledge	The students know a	bout the most ir	mportant technologies a	nd materials of MEMS as well as	their applica	tions in sensors and
	actuators.					
<i></i>						
Skills		analyze and de	escribe the functional b	ehaviour of MEMS components	and to evalu	ate the potential of
	microsystems.					
Personal Competence						
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.					
Autonomy		acquire particula	r knowledge using specia	alized literature and to integrate	and associate	this knowledge with
	other fields.					
Workload in Hours	Independent Study Ti	me 124, Study Ti	me in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation				
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	Electrical Engineering	: Core Qualificati	on: Compulsory			
Following Curricula	International Manage	ment and Engine	ering: Specialisation II. El	ectrical Engineering: Elective Cor	npulsory	
	International Manage	ment and Engine	ering: Specialisation II. M	echatronics: Elective Compulsory		
	Mechanical Engineeri	ng and Managem	ent: Specialisation Mech	atronics: Elective Compulsory		
	Mechatronics: Specia	lisation System D	esign: Elective Compulso	ory		
	Biomedical Engineering	ng: Specialisation	Artificial Organs and Re	generative Medicine: Elective Cor	npulsory	
	Biomedical Engineering	ng: Specialisation	Implants and Endoprost	heses: Elective Compulsory		
	Biomedical Engineering	ng: Specialisation	Medical Technology and	Control Theory: Elective Compul	sory	
	Biomedical Engineering	ng: Specialisation	Management and Busin	ess Administration: Elective Comp	oulsory	
	Microelectronics and	Microsystems: Co	ore Qualification: Elective	Compulsory		
	Theoretical Mechanic	al Engineering: Te	echnical Complementary	Course: Elective Compulsory		
	Theoretical Mechanic	al Engineering: Sp	pecialisation Bio- and Me	dical Technology: Elective Compu	Ilsory	

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

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

Module M0751: Vibra	tion Theory	
Courses		
Title	Typ Hrs/wk CP	
Vibration Theory (L0701)	Integrated Lecture 4 6	
Module Responsible	Prof. Norbert Hoffmann	
Admission Requirements	None	
Recommended Previous Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them further.	
Skills	Students are able to denote methods of Vibration Theory and develop them further.	
Personal Competence		
Social Competence	Students can reach working results also in groups.	
Autonomy	Students are able to approach individually research tasks in Vibration Theory.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points	6	
Course achievement	None	
Examination	Written exam	
Examination duration and scale		
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory	
Following Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory	
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: 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 Management and Business Administration: Elective Compulsory	
	Product Development, Materials and Production: Core Qualification: Compulsory	
	Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory	

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

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Courses				
Title		Тур	Hrs/wk	СР
Technology Management (L0849) Technology Management Seminar	(1.0850)	Project-/problem-based Learning Project-/problem-based Learning	3 2	3 3
	Prof. Cornelius Herstatt		2	5
Admission Requirements	Bachelor knowledge in business management			
Knowledge	bachelor knowledge in business management			
	After taking part successfully, students have reach	ed the following learning results		
Professional Competence	Arter taking part successiony, students have reach			
	Students will gain deep insights into:			
Knowledge	Students will guilt deep insignes into.			
	 International R&D-Management 			
	Technology Timing Strategies			
	 Technology Strategies and Lifecycle N 			
	 Technology Intelligence and Planning 			
	Technology Portfolio Management Technology Portfolio Mathedalagy			
	 Technology Portfolio Methodology Technology Acquisition and Exploitati 	on		
	IP Management			
	Organizing Technology Development			
	 Technology Organization & Managem 	ent		
	 Technology Funding & Controlling 			
Skills	The course aims to:			
	Develop an understanding of the importance Develop an understanding of the importance			
	 Equip students with an understanding organizational and process-related aspects) 		lagement (su	ategic, operatio
	 Foster a strategic orientation to problem-so 		s Technology I	Management and
	importance for corporate strategy		, recrimology i	indiagement and
	 Clarify activities of Technology Management 	t (e.g. technology sourcing, maintenance and e	exploitation)	
	 Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues 			
	concerning Technology-, Innovation- and R&	D-management. Further topics to be discusse	d include:	
	Basic concepts, models and tools, relevant t		novation	
	 Innovation as a process (steps, activities and 	d results)		
Personal Competence				
Social Competence				
	Interact within a team			
	 Raise awareness for globabl issues 			
Autonomy				
	Gain access to knowledge sources			
	 Discuss recent research debates in the cont Develop presentation skills 	ext of Technology and Innovation Managemen	L	
	 Discussion of international cases in R&D-Ma 	nagement		
Workload in Hours Credit points	Independent Study Time 110, Study Time in Lectur 6	re 70		
Course achievement				
Examination				
Examination duration and				
scale				
	Global Innovation Management: Core Qualification:	: Compulsory		
-	International Management and Engineering: Specia		npulsorv	
	Mechanical Engineering and Management: Special	•		
	Biomedical Engineering: Specialisation Artificial Or		npulsory	
	Biomedical Engineering: Specialisation Implants an		-	
	Biomedical Engineering: Specialisation Medical Teo	chnology and Control Theory: Elective Compute	sory	
	Biomedical Engineering: Specialisation Management	nt and Business Administration: Compulsory		

Course L0849: Technology M	lanagement
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	The role of technology for the competitive advantage of the firm and industries; Basic concepts, models and tools for the management of technology; managerial decision making regarding the identification, selection and protection of technology (make or buy, keep or sell, current and future technologies). Theories, practical examples (cases), lectures, interactive sessions and group study. This lecture is part of the Module Technology Management and can not separately choosen.
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	anagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Courses							
Courses				-	11		
Title Microsystems Technology (L0724)				Typ Lecture	Hrs/wk 2	CP 4	
Microsystems Technology (L0725)				Project-/problem-based Learning	2	2	
Module Responsible	Prof. Hoc Khiem Trieu	ı					
Admission Requirements	None						
Recommended Previous	Basics in physics, che	emistry, mechanics and	semiconductor techn	nology			
Knowledge							
Educational Objectives	After taking part succ	cessfully, students have	reached the following	g learning results			
Professional Competence	Students are able						
Kilowieuge	Students are able						
	-			or microstructures and especie of in more complex systems	ally methods f	or the fabrication	
	• to explain in deta	ails operation principles	of microsensors and	microactuators and			
	to discuss the point	tential and limitation of	microsystems in app	blication.			
Skills	Students are capable	2					
	 to analyze the feasibility of microsystems, 						
	 to develop process flows for the fabrication of microstructures and 						
	 to apply them. 						
Personal Competence							
Social Competence							
	Students are able to pof audience.	prepare and perform th	eir lab experiments i	n team work as well as to pres	ent and discus	is the results in fro	
Autonomy	None						
Workload in Hours	Independent Study Ti	ime 124, Study Time in	Lecture 56				
Credit points		ine 124, study line in					
Course achievement		Form	Description				
	Yes None	Subject theoretical practical work		führen in Kleingruppen ein La nd diskutiert die Theorie sowie mten Kurs.			
Examination	Oral exam						
Examination	30 min						
Examination duration and							
Examination duration and scale			ectronics and Microsy	stems Technology: Elective Co	mpulsory		
Examination duration and scale Assignment for the							
Examination duration and scale Assignment for the	Electrical Engineering	g: Specialisation Medical	Technology: Elective	e Compulsory			
Examination duration and scale Assignment for the	Electrical Engineering International Manage	g: Specialisation Medical ment and Engineering:	Technology: Elective Specialisation II. Mec				
Examination duration and scale Assignment for the	Electrical Engineering International Manage Biomedical Engineerin	g: Specialisation Medical ment and Engineering: ng: Specialisation Artific	Technology: Elective Specialisation II. Mec ial Organs and Rege	e Compulsory hatronics: Elective Compulsory			
Examination duration and scale Assignment for the	Electrical Engineering International Manage Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin	g: Specialisation Medical ment and Engineering: ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic	Technology: Elective Specialisation II. Mec cial Organs and Regents and Endoprosthe cal Technology and Co	e Compulsory hatronics: Elective Compulsory nerative Medicine: Elective Cor	npulsory sory		

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

Course L0725: Microsystems	ırse L0725: Microsystems Technology				
Тур	Project-/problem-based Learning				
Hrs/wk					
СР	2				
Workload in Hours	pendent Study Time 32, Study Time in Lecture 28				
Lecturer	Hoc Khiem Trieu				
Language	EN				
Cycle	WiSe				
Content	See interlocking course				
Literature	See interlocking course				

Courses						
		T	Hare to de	CP		
Title Control Systems Theory and Desigr	(10656)	Typ Lecture	Hrs/wk 2	CP 4		
Control Systems Theory and Design		Recitation Section (small)	2	2		
Module Responsible			_	_		
Admission Requirements						
	Introduction to Control Systems					
Knowledge						
	After taking part successfully, students ha	ave reached the following learning results				
Professional Competence	51					
Knowledge						
-		lynamic systems are represented as state space r	nodels; they can	interpret the sys		
		al excitation as trajectories in state space				
		erties controllability and observability, and their re	lationship to stat	e feedback and s		
	estimation, respectively					
	They can explain the significance of the second secon					
		tate feedback and how it can be used to achieve tr	acking and distur	bance rejection		
	They can extend all of the above to					
		nd its relationship with the Laplace Transform	stame			
		els and transfer function models of discrete-time sy identification of ARX models of dynamic systems, a		tification problem		
	be solved by solving a normal equa					
	, , ,	e model can be constructed from a discrete-time in	nulse response			
	- mey can explain now a state space					
Skills	 Students can transform transfer ful 	nction models into state space models and vice ver	5 3			
			50			
	 They can assess controllability and observability and construct minimal realisations They can decign LOG controllers for multivariable plants. 					
	 They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriately a controller design both in continuous-time and discrete-time domain. 					
	 They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropria for a given sampling rate 					
	 They can identify transfer function models and state space models of dynamic systems from experimental data 					
	They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox)					
	Simulink)					
Personal Competence						
Social Competence	Students can work in small groups on spe	cific problems to arrive at joint solutions.				
Autonomy	Students can obtain information from pr	ovided sources (lecture notes, software documen	tation, experime	nt guides) and u		
	when solving given problems.					
	They can assess their knowledge in weekly on-line tests and thereby control their learning progress.					
	They can assess their knowledge in week	ly on-line tests and thereby control their learning p	rogress.			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56				
Credit points	6					
Course a shiouse at	No.					
Course achievement						
Examination						
Examination duration and	120 min					
scale		C				
-	Electrical Engineering: Core Qualification:					
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory					
	, , ,					
	Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory					
	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory					
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory					
	Mechatronics: Core Qualification: Compul					
		tificial Organs and Regenerative Medicine: Elective	Compulsory			
		plants and Endoprostheses: Elective Compulsory	compaisory			
		edical Technology and Control Theory: Compulsory				
	• • •	anagement and Business Administration: Elective C	ompulsory			
		uction: Core Qualification: Elective Compulsory				

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

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

C						
Courses						
Title		Тур	Hrs/wk	СР		
The Digital Enterprise (L0932)	2220	Lecture	2	2		
Production Planning and Control (L Production Planning and Control (L		Lecture Recitation Section (small)	2 1	2 1		
Exercise: The Digital Enterprise (L0		Recitation Section (small)	1	1		
	Prof. Hermann Lödding					
Admission Requirements	None					
Recommended Previous	Fundamentals of Production and Quality	Management				
Knowledge						
Educational Objectives	After taking part successfully, students h	nave reached the following learning results				
Professional Competence						
Knowledge	Students can explain the contents of the	Students can explain the contents of the module in detail and take a critical position to them.				
Skills	Students are capable of choosing and ap	Students are capable of choosing and applying models and methods from the module to industrial problems.				
Personal Competence						
Social Competence	itudents can develop joint solutions in mixed teams and present them to others.					
Autonomy						
Workload in Hours	ndependent Study Time 96, Study Time in Lecture 84					
Credit points	5					
Course achievement	None					
Examination	Written exam					
Examination duration and	180 Minuten					
scale						
Assignment for the	International Management and Engineer	ing: Specialisation II. Product Development and Product	uction: Elective C	ompulsory		
Following Curricula	Logistics, Infrastructure and Mobility: Spo	ecialisation Production and Logistics: Elective Compu	lsory			
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elective	Compulsory			
	Biomedical Engineering: Specialisation Ir	nplants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Elective Com	pulsory			
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Compulsor	ГУ			
	Product Development, Materials and Pro	duction: Specialisation Product Development: Electiv	e Compulsory			
	Product Development, Materials and Pro	duction: Specialisation Production: Compulsory				
	Product Development, Materials and Pro	duction: Specialisation Materials: Elective Compulsor	У			
	Theoretical Mechanical Engineering: Spe	cialisation Product Development and Production: Ele	ctive Compulsory			
	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Compulsory				

Course L0932: The Digital Er	iterprise
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered. Content: • Business Process Management and Data Modelling, Simulation • Knowledge and Competence Management • Process Management (PPC, Workflow Management) • Computer Aided Planning (CAP) and NC-Programming • Virtual Reality (VR) and Augmented Reality (AR) • Computer Aided Quality Management (CAQ) • Industry 4.0
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002 Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006 Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004 Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007 Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006

Course L0929: Production Pla	anning and Control
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002

Course L0930: Production Pl	urse L0930: Production Planning and Control			
Тур	Recitation Section (small)			
Hrs/wk	1			
CP	1			
Workload in Hours	pendent Study Time 16, Study Time in Lecture 14			
Lecturer	. Hermann Lödding			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Course L0933: Exercise: The	Digital Enterprise			
Тур	Recitation Section (small)			
Hrs/wk	1			
СР				
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Dr. Axel Friedewald			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	Siehe korrespondierende Vorlesung			
	See interlocking course			

Module M0921: Electi						
Courses						
Title Electronic Circuits for Medical Applications (L0696) Electronic Circuits for Medical Applications (L1056) Electronic Circuits for Medical Applications (L1408)				Typ Lecture Recitation Section (small)	Hrs/wk 2 1	CP 3 2
	1			Practical Course	1	1
Module Responsible						
Admission Requirements Recommended Previous		al engineering				
Knowledge						
Educational Objectives	After taking part succes	fully, students have	reached the follow	ing learning results		
Professional Competence Knowledge	 Students can exp Students are able Students can exp Students can des Students can exp 	to explain the build-u mplify the communica cribe the special featu lain the functions of p	up of an action pot ation between neu ures of low-noise a prostheses, e. g. ar	ation transfer by the central ential and its propagation alo rons and electronic devices mplifiers for medical applicat a artificial hand of cochlea implants and artif	ong an axon ions	
Skills	 Students can calculate the time dependent voltage behavior of an action potential Students can give scenarios for further improvement of low-noise and low-power signal acquisition. Students can develop the block diagrams of prosthetic systems Students can define the building blocks of electronic systems for an articifial eye. 					
Personal Competence Social Competence	 Students are tra professional back Students are able 	ground. to recognize their sp ument their work in	ecific limitations, s	medical electronics in teams to that they can ask for assist id communicate their results	ance to the right	time.
Autonomy	necessary. • Students can bre • Students can har	ak down their work in dle the complex data	appropriate work structures of bioel	their knowledge and to de packages and schedule their ectrical experiments without ses and situations of experim	work in a realistic needing support.	
Workload in Hours	Independent Study Time	124, Study Time in I	_ecture 56			
Credit points	6					
Course achievement	Yes None	orm Subject theoretical Iractical work Excercises	Description and			
Examination	Written exam					
Examination duration and scale	90 min					
Assignment for the Following Curricula	Biomedical Engineering Biomedical Engineering Biomedical Engineering Microelectronics and Mi	Specialisation Artifici Specialisation Implar Specialisation Medic Specialisation Manac rosystems: Specialisa	ial Organs and Reg nts and Endoprosth al Technology and gement and Busine ation Microelectror	ve Compulsory Jenerative Medicine: Elective Neses: Elective Compulsory Control Theory: Compulsory Iss Administration: Elective Co Nics Complements: Elective Co Course: Elective Compulsory	ompulsory	

Course L0696: Electronic Cire	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	 Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Cire	Course L1056: Electronic Circuits for Medical Applications	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Matthias Kuhl	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1408: Electronic Cir	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	 Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Module M1150: Conti	nuum Mechanics				
C					
Courses					
Title Continuum Mechanics (L1533)		Тур	Hrs/wk	СР 3	
Continuum Mechanics (L1533) Continuum Mechanics Exercise (L1	534)	Lecture Recitation Section (small)	2	3	
Module Responsible	1		-	5	
Admission Requirements	None				
Recommended Previous	Basics of linear continuum mechanics as taught	e.g., in the module Mechanics II (forces an	d moments, stre	ss. linear strain. fre	
Knowledge	-	•			
Educational Objectives	After taking part successfully, students have read	ched the following learning results			
Professional Competence					
Knowledge					
	The students can explain the fundamental conce	pts to calculate the mechanical behavior of r	materials.		
Skills	The students can set up balance laws and apply	basics of deformation theory to specific a	spects, both in a	pplied contexts as	
	research contexts.				
Personal Competence					
Social Competence	The students are able to develop solutions, to pro-	esent them to specialists in written form and	to develop ideas	further.	
Autonomy	The students are able to assess their own streng		-	wn identify and solv	
	problems in the area of continuum mechanics an	d acquire the knowledge required to this end	d.		
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	45 min				
scale					
Assignment for the	Materials Science: Specialisation Modeling: Elect	ve Compulsory			
Following Curricula	Mechanical Engineering and Management: Speci	alisation Materials: Elective Compulsory			
	Mechatronics: Technical Complementary Course: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial 0	Organs and Regenerative Medicine: Elective	Compulsory		
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Elective Com	pulsory		
	Biomedical Engineering: Specialisation Managem	ent and Business Administration: Elective Co	ompulsory		
	Product Development, Materials and Production:				
	Theoretical Mechanical Engineering: Technical Co				
	Theoretical Mechanical Engineering: Core Qualifi	cation: Elective Compulsory			

Course L1533: Continuum Me	echanics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	 kinematics of undeformed and deformed bodies balance equations (balance of mass, balance of energy,) stress states material modelling
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

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

Module M1151: Mate	rial Modeling			
Courses				
Title		Turn	Hrs/wk	СР
Material Modeling (L1535)		Typ Lecture	2	3
Material Modeling (L1535) Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum mechanics	as taught, e.g., in the modules Mechanic	s II and Continuu	m Mechanics (force
Knowledge	and moments, stress, linear and nonlinear strain, fre	ee-body principle, linear and nonlinear con	stitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multion	dimensional consitutive material laws		
Skills	The students can implement their own material law	s in finite element codes. In particular, the	e students can a	pply their knowledg
	to various problems of material science and evaluat	e the corresponding material models.		
Personal Competence				
	The students are able to develop solutions, to prese	nt them to specialists and to develop idea	s further.	
Autonomy	The students are able to assess their own strengths	and weaknesses. They can independently	v and on their o	vn identify and solv
, laconomy	problems in the area of materials modeling and acquire the knowledge required to this end.			
	problems in the area of materials modeling and acq	and the knowledge required to this end.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective	Compulsory		
Following Curricula	Mechanical Engineering and Management: Specialis	ation Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	ans and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Co	re Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation N	Naterials Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation S	imulation Technology: Elective Compulso	ry	

Course L1535: Material Mode	eling
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials) - plasticity (permanent deformation due to one-time overload, e.g., in metal forming) - viscoelasticity (absorption of energy, e.g., in dampers) - creep (slow deformation under permanent load, e.g., in pipes)
	This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.
Literature	

Course L1536: Material Mode	eling
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1199: Adva	nced Functional Materials				
Courses					
Title		Тур	Hrs/wk	СР	
Advanced Functional Materials (L1)	525)	Seminar	2	6	
Module Responsible	Prof. Patrick Huber				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.	3. Materials Science I/II			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particula metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.				
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design ne materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview o modern materials science, which enables them to select optimum materials combinations depending on the technica applications.				
Personal Competence					
Social Competence	The students are able to present solution	as to specialists and to develop ideas further.			
Autonomy	The students are able to				
	assess their own strengths and weaknesses.				
	 gather new necessary expertise by 	y their own.			
Workload in Hours	Independent Study Time 152, Study Time	e in Lecture 28			
Credit points	6				
Course achievement	None				
Examination	Presentation				
Examination duration and	30 min				
scale					
Assignment for the	Materials Science: Core Qualification: Con	mpulsory			
Following Curricula	Mechanical Engineering and Managemen	t: Specialisation Materials: Elective Compulsory	У		
	• • •	rtificial Organs and Regenerative Medicine: Ele			
	• • •	nplants and Endoprostheses: Elective Compulse			
	5 5 1	ledical Technology and Control Theory: Elective	1		
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
		hnical Complementary Course: Elective Compu			
	Theoretical Mechanical Engineering: Spe	cialisation Materials Science: Elective Compulse	ory		

Course L1625: Advanced Fun	ictional Materials
Тур	Seminar
Hrs/wk	2
СР	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Christian Cyron, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Stefan Fritz Müller
Language	DE
Cycle	WiSe
Content	1. Porous Solids - Preparation, Characterization and Functionalities
	2. Fluidics with nanoporous membranes
	3. Thermoplastic elastomers
	4. Optimization of polymer properties by nanoparticles
	5. Fiber composites in automotive
	6. Modeling of materials based on quantum mechanics
	7. Biomaterials
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.

Module M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)

-					
Courses					
Title		Тур	Hrs/wk	CP	
Nature's Hierarchical Materials (L16		Seminar	2	3	
-	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4	
-	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2	
Development and Regulatory Appro	-	Lecture	2	3	
Experimental Methods for the Char		Lecture	2	3	
Numerical Methods in Biomechanic		Seminar Seminar	2	3	
Seminar Biomedical Engineering (L Six Sigma (L1130)	1030)	Lecture	2	3	
Fluid Mechanics II (L0001)		Lecture	2	4	
System Simulation (L1820)		Lecture	2	2	
System Simulation (L1821)		Recitation Section (large)	1	2	
Ceramics Technology (L0379)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous					
Knowledge					
Educational Objectives	After taking part successfully, students have reached	After taking part successfully, students have reached the following learning results			
Professional Competence					
Knowledge					
Skills					
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Depends on choice of courses				
Credit points	12				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective	Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory			
-	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				

Course L1663: Nature's Hierarchical Materials			
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and			
scale			
Lecturer	Prof. Gerold Schneider		
Language	EN		
Cycle	WiSe		
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a		
	diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological		
	materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have cataly		
	function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc. This lecture will focus on material		
	with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea),		
	mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of		
	the structure in these materials and how these structures relate to their (mostly mechanical) functions.		
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334		
	Journal publications		

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Lecture		
Hrs/wk			
СР			
	Independent Study Time 78, Study Time in Lecture 42		
Examination Form			
Examination duration and			
scale			
Lecturer	Prof. Christian Schuster		
Language			
Cycle			
	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagati and Electromagnetic Compatibility will be introduced and discussed.		
	Topics:		
	- Fundamental properties and phenomena of electrical circuits		
	- Steady-state sinusoidal analysis of electrical circuits		
	- Fundamental properties and phenomena of electromagnetic fields and waves		
	- Steady-state sinusoidal description of electromagnetic fields and waves		
	- Useful microwave network parameters		
	- Transmission lines and basic results from transmission line theory		
	- Plane wave propagation, superposition, reflection and refraction		
	 General theory of waveguides Most important types of waveguides and their properties 		
	- Radiation and basic antenna parameters		
	- Most important types of antennas and their properties		
	- Numerical techniques and CAD tools for waveguide and antenna design		
	- Fundamentals of Electromagnetic Compatibility		
	- Coupling mechanisms and countermeasures		
	- Shielding, grounding, filtering		
	- Standards and regulations		
	- EMC measurement techniques		
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)		
Literature	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)		
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)		
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)		
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)		
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)		

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility				
Тур	ecitation Section (small)			
Hrs/wk				
СР				
Workload in Hours	lependent Study Time 32, Study Time in Lecture 28			
Examination Form	liche Prüfung			
Examination duration and	0 min			
scale				
Lecturer	of. Christian Schuster			
Language)E/EN			
Cycle	oSe			
Content	See interlocking course			
Literature	ee interlocking course			

Course L1588: Development	and Regulatory Approval of Implants		
Тур	Lecture		
Hrs/wk	2		
СР	\$		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Roman Nassutt		
Language	DE		
Cycle	WiSe		
Content			
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html 		

Course L1580: Experimental	Methods for the Characterization of Materials		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber		
Language	DE		
Cycle	WiSe		
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry) 		
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).		

Course L1583: Numerical Me	thods in Biomechanics		
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	SoSe		
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 		
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009		

Course L1890: Seminar Biomedical Engineering			
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Examination Form	leferat		
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	Se		
Content			
Literature	eine		

Course L1130: Six Sigma			
Тур	Lecture		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 		
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008		

Typ Lecture Hrs/wk 2 CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Examination Form Klausur Examination duration and scale Prof. Michael Schlüter Lecturer Prof. Michael Schlüter Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Examination Form Klausur Examination duration and scale Prof. Michael Schlüter Lecturer Prof. Michael Schlüter DE Wise Content • Differential equations for momentum-, heat and mass transfer	
Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Examination Form Klausur Examination duration and scale Prof. Michael Schlüter Lecturer Prof. Michael Schlüter Language DE Content • Differential equations for momentum-, heat and mass transfer	
Examination Form Klausur Examination duration and scale Prof. Michael Schlüter Lecturer Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
Examination duration and scale Prof. Michael Schlüter Lecturer Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
scale Lecturer Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
Lecturer Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer	
• Differential equations for momentum-, heat and mass transfer	
 Differential equations for momentum-, heat and mass transfer 	
 Examples for simplifications of the Navier-Stokes Equations 	
Unsteady momentum transfer	
Free shear layer, turbulence and free jets	
Flow around particles - Solids Process Engineering	
Coupling of momentum and heat transfer - Thermal Process Engineering	
Rheology – Bioprocess Engineering	
Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering	
 Flow threw porous structures - heterogeneous catalysis Pumps and turbines - Energy- and Environmental Process Engineering 	
 Pumps and turbines - Energy- and Environmental Process Engineering Wind- and Wave-Turbines - Renewable Energy 	
Introduction into Computational Fluid Dynamics	
Literature 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frank	
2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972	
3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.	
 Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verla 2006. 	ıg, Berlin, Heidelberg,
5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.	
 Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modelliere Springer Verlag, Berlin, Heidelberg, New York, 2006. 	ung von Strömungen
 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+T Fachverlage GmbH, Wiesbaden, 2008. 	eubner Verlag / GWV
8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele GWV Fachverlage GmbH, Wiesbaden, 2009. 	e. Vieweg+ Teubner ,
10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.	
 Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständ Verlag, Berlin, Heidelberg, 2008. 	liger Fluide. Springer
12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.	
13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.	

Course L1820: System Simul	ation			
Тур	Lecture			
Hrs/wk				
CP	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Examination Form	Mündliche Prüfung			
Examination duration and	30 min			
scale				
Lecturer	Dr. Stefan Wischhusen			
Language	DE			
Cycle	WiSe			
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems			
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011. 			

Course L1821: System Simulation				
Тур	ecitation Section (large)			
Hrs/wk				
СР				
Workload in Hours	ependent Study Time 46, Study Time in Lecture 14			
Examination Form	iche Prüfung			
Examination duration and) min			
scale				
Lecturer	r. Stefan Wischhusen			
Language	DE			
Cycle	ViSe			
Content	See interlocking course			
Literature	ee interlocking course			

Course L0379: Ceramics Technology			
Тур	Lecture		
Hrs/wk			
CP			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Rolf Janßen		
Language			
Cycle	WiSe		
Content	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder- based processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components. Content: 1. Introduction Inhalt: 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques		
Literature	W.D. Kingery, "Introduction to Ceramics", John Wiley & Sons, New York, 1975 ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991 D.W. Richerson, "Modern Ceramic Engineering", Marcel Decker, New York, 1992		
	Skript zur Vorlesung		

Courses				
Courses				
Title Introduction to Biochemistry and M	olocular Piology (10296)	Typ Lecture	Hrs/wk 2	СР 3
		Lecture	Ζ.	2
-	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	The students can			
	 describe basic biomolecules; 			
	explain how genetic information is a	oded in the DNA;		
	explain the connection between DN	A and proteins;		
CL ///-	The state is a second			
Skills	The students can			
	 recognize the importance of molecular 	lar parameters for the course of a disease;		
	describe selected molecular-diagnos	stic procedures;		
	explain the relevance of these proce	edures for some diseases		
Deveenal Competence				
Personal Competence	The students can participate in discussion	in recearch and modicine on a technical lo	vol	
Social Competence	The students can participate in discussions	s in research and medicine on a technical lev	vei.	
Autonomy	The students can develop understanding c	f topics from the course, using technical lite	erature, by themselves.	
Workload in Hours	Independent Study Time 62, Study Time in	Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German pro	gram, 7 semester): Specialisation Biomedica	al Engineering: Compulsory	/
Following Curricula		program, 7 semester): Specialisation Med		
	Compulsory			
	Data Science: Specialisation Medicine: Cor	npulsory		
	Electrical Engineering: Specialisation Medi	cal Technology: Elective Compulsory		
	Engineering Science: Specialisation Biome	dical Engineering: Compulsory		
	General Engineering Science (English prog	ram, 7 semester): Specialisation Biomedical	l Engineering: Compulsory	
	General Engineering Science (English p	rogram, 7 semester): Specialisation Med	chanical Engineering, Foo	cus Biomechani
	Compulsory			
	Mechanical Engineering: Specialisation Bio	mechanics: Compulsory		
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration: Elec	ctive Compulsory	
	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medicine: El	ective Compulsory	
	5 5 1	dical Technology and Control Theory: Electiv		
	Biomedical Engineering: Specialisation Imp	plants and Endoprostheses: Elective Compul	sory	
	Technomathematics: Specialisation III. Eng	ineering Science: Elective Compulsory		

Course L0386: Introduction t	to Biochemistry and Molecular Biology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008

C				
Courses				
Title		Тур	Hrs/wk	СР 3
Implants and Fracture Healing (L03		Lecture	2	3
Module Responsible				
Admission Requirements				
	It is recommended to participate in "Introduction into	Anatomie" before attending "Imp	olants and Fracture Heali	ng".
Knowledge				
-	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how bor			
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.			
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			fic assumptions.
	5			
Personal Competence				
Social Competence	The students can, in groups, solve basic numerical me	odeling tasks for the calculation o	of internal forces.	
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
		-		
	Independent Study Time 62, Study Time in Lecture 28			
Credit points				
Course achievement				
	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program, 7	semester): Specialisation Mec	chanical Engineering, F	ocus Biomechan
Following Curricula	Compulsory			
	General Engineering Science (German program, 7 ser		l Engineering: Compulso	ory
	Engineering Science: Specialisation Biomedical Engin			
	General Engineering Science (English program, 7 sem	ester): Specialisation Biomedical	Engineering: Compulsor	У
	General Engineering Science (English program, 7	semester): Specialisation Mec	hanical Engineering, F	ocus Biomechan
	Compulsory			
	Mechanical Engineering: Specialisation Biomechanics	: Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Comput	sory	
	Biomedical Engineering: Specialisation Medical Techn		-	
	Biomedical Engineering: Specialisation Management			
	Orientierungsstudium: Core Qualification: Elective Co		and compaisony	
	Shendara angostaanan. Core Quanneation. Elective Co			
	Technomathematics: Specialisation III. Engineering So	ience: Elective Compulsory		

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	
Content	Topics to be covered include:
	1. Introduction (history, definitions, background importance)
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)
	3.1 The spine in its entirety
	3.2 Cervical spine
	3.3 Thoracic spine
	3.4 Lumbar spine
	3.5 Injuries and diseases
	4. Pelvis (anatomy, biomechanics, fracture treatment)
	5 Fracture Healing
	5.1 Basics and biology of fracture repair
	5.2 Clinical principals and terminology of fracture treatment
	5.3 Biomechanics of fracture treatment
	5.3.1 Screws
	5.3.2 Plates
	5.3.3 Nails
	5.3.4 External fixation devices
	5.3.5 Spine implants
	6.0 New Implants
Literature	Cochran V.B.: Orthopädische Biomechanik
Literature	
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students l	have reached the following learning results		
Professional Competence	The students are describe the meterials			in a state the size field
Knowledge	Knowledge The students can describe the materials of the human body and the materials being used in medical engineering, and use.			ing, and their field
	use.			
Skills	The students can explain the advantage	es and disadvantages of different kinds of bior	materials.	
Personal Competence				
•	The students are able to discuss issues	related to materials being present or being u	used for replacements wit	th student mates a
	the teachers.			
Autonomy	The students are able to acquire inform	ation on their own. They can also judge the in	formation with record to	ite credibility
Autonomy	The students are able to acquire morna	ation on their own. They can also judge the in	normation with respect to	o its credibility.
Workload in Hours	Independent Study Time 62, Study Time	e in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
-	• •	ring: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula		nd Hybrid Materials: Elective Compulsory		
	• • •	Artificial Organs and Regenerative Medicine: E	Elective Compulsory	
		mplants and Endoprostheses: Compulsory Aedical Technology and Control Theory: Elect	ive Compulsory	
	• • •	Medical rechnology and control meory: Elect Management and Business Administration: Elect		
		chnical Complementary Course: Elective Com		
		ecialisation Bio- and Medical Technology: Elec		

ourse L0593: Biomaterials	
	Lecture
Hrs/wk CP	
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	Topics to be covered include:
	1. Introduction (Importance, nomenclature, relations)
	2. Biological materials
	2.1 Basics (components, testing methods)
	2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which as used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
Encontraite	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.
	materialite, 21 and ho, 5. W. Biokompausie Werksteine and Bauweisen. Bernin, Springer, 1990.

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Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291) Finite Element Methods (L0804)		Lecture Recitation Section (large)	2 2	3 3
Module Responsible	Prof. Otto von Estorff			-
Admission Requirements	None			
	Mechanics I (Statics, Mechanics of Materials) and Me	echanics II (Hydrostatics, Kinematics, Dyna	amics)	
Knowledge	Mathematics I, II, III (in particular differential equation			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	Arter taking part successiony, students have reache	d the following learning results		
	The students persons on in depth knowledge reg	ording the derivation of the finite element	nt mothod and	ara abla ta giva
Kilowieuge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to g overview of the theoretical and methodical basis of the method.		are able to give	
		the method.		
Skills	The students are capable to handle engineering pr	oblems by formulating suitable finite eler	ments assemblin	a the correspond
SKIIS	system matrices, and solving the resulting system o		nents, assemblin	g the correspond
	system matrices, and solving the resulting system o			
Personal Competence				
Social Competence	Students can work in small groups on specific proble	ems to arrive at joint solutions.		
Autonomy	The students are able to independently solve cha		evelop own finit	e element routir
	Problems can be identified and the results are critica	ally scrutinized.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement		Description		
	No 20 % Midterm			
Examination				
Examination duration and	120 min			
scale Assignment for the	Civil Engineering: Core Qualification: Compulsory			
-	Energy Systems: Core Qualification: Elective Compu	loop		
Following curricula	Aircraft Systems Engineering: Specialisation Aircraft	,		
	Aircraft Systems Engineering: Specialisation Aircraft			
	Aircraft Systems Engineering: Specialisation Aircraft			
	Aircraft Systems Engineering: Specialisation Air Tran			
	International Management and Engineering: Special			
	International Management and Engineering: Special		-	
	International Management and Engineering: Special			ompulsorv
	International Management and Engineering: Special			
	Mechatronics: Core Qualification: Compulsory			1
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Compulsorv		
	Biomedical Engineering: Specialisation Management	1 1 5	mpulsory	
	Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Artificial Orga		-	
	Product Development, Materials and Production: Con	-		
	Technomathematics: Specialisation III. Engineering			
	Technomathematics: Specialisation III. Engineering S	Science: Elective Compulsory		

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

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

Courses					
Title		Тур	Hrs/wk	СР	
Structure and Properties of Polyme Processing and design with polyme		Lecture Lecture	2	3 3	
Module Responsible				-	
Admission Requirements	None				
Recommended Previous	Basics: chemistry / physics / material scie	nce			
Knowledge					
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results			
Professional Competence					
Knowledge	Students can use the knowledge of plasti	cs and define the necessary testing and analy	sis.		
	They can explain the complex relationship	ps structure-property relationship and			
	the interactions of chemical structure of t	he polymers, including to explain neighboring	contexts (e.g. sustaina	ability, environment	
	protection).				
Skills	Students are canable of				
SKIIIS	Students are capable of				
	-	ds in a given context to mechanical prope	rties (modulus, streng	th) to calculate a	
	evaluate the different materials.				
	- selecting appropriate solutions for mech	hanical recycling problems and sizing example	e stiffness, corrosion re	sistance.	
Personal Competence					
Social Competence	Students can				
	 arrive at funded work results in heteroge 	enius groups and document them.			
	- provide appropriate feedback and handl	e feedback on their own performance constru	ctively.		
Autonomy	Students are able to				
	- assess their own strengths and weaknesses.				
	- assess their own state of learning in specific terms and to define further work steps on this basis.				
	- assess possible consequences of their professional activity.				
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 min				
scale	Meteriala Caisana Cassialization Frances	rine Meteriale: Elective Computerno			
Following Curricula	Materials Science: Specialisation Enginee Biomedical Engineering: Specialisation Im	5 1 5			
. eenning carricula	5 5 1	tificial Organs and Regenerative Medicine: Ele	ctive Compulsory		
		anagement and Business Administration: Elect			
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective	e Compulsory		
		uction: Specialisation Production: Elective Cor			
		uction: Specialisation Materials: Elective Com	-		
		uction: Specialisation Product Development: E nical Complementary Course: Elective Compu			
	Theoretical Mechanical Engineering: Tech Theoretical Mechanical Engineering: Spec				

Course 1.0200. Characteria and		
Course L0389: Structure and		
	Lecture	
Hrs/wk		
СР		
	Independent Study Time 62, Study Time in Lecture 28	
	r. Hans Wittich	
Language		
Cycle	WiSe	
Content	- Structure and properties of polymers	
	- Structure of macromolecules	
	Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution	
	- Morphology	
	amorph, crystalline, blends	
	- Properties	
	Elasticity, plasticity, viscoelacity	
	- Thermal properties	
	- Electrical properties	
	- Theoretical modelling	
	- Applications	
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag	

Course L1892: Processing an	nd design with polymers
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich
Language	DE/EN
Cycle	WiSe
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining
	Designing with Polymers: Materials Selection; Structural Design; Dimensioning
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag
	Crawford: Plastics engineering, Pergamon Press
	Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag
	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Regenerative Medicine (L1664)			Seminar	2	3
)	Seminar	2	3
Module Responsible					
Admission Requirements					
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part succ	essfully, students have i	eached the following learning results		
Professional Competence			u dente util he ekte te desetihe the kee		
Knowledge			udents will be able to describe the bas methods of tissue engineering. They are		
	the cultivation of anir		methous of tissue engineering. They are	e able to give a basic ovi	erview of methods
	The students can ou	utline the actual conce	pts of Tissue Engineering and regener	rative medicine and ca	an explain the bas
	udnerlying principles	of the discussed topics.			
CI-III-	A 64		danta ana		
SKIIIS	After successful comp	pletion of the module stu	dents are		
	 able to use me 	dical databases for acqu	irierung and presentation of relevant up-	to-date data independe	ntly
	 able to present 	their work results in the	e form of presentations		
	 able to carry or 	ut basic cell culture metl	nods and the corresponding analysis inde	ependently	
	 able to analyse 	e and evaluate current re	esearch topics for Tissue Engineering and	l regenerative medicine.	
Personal Competence					
Social Competence	Students are able to	work together as a team	with 2-4 students to solve given tasks a	nd discuss their results	in the plenary and
	defend them.				
	Students are able to u	offect their work erally a	nd discuss it with other students and tea	schors	
		enect their work orany a		ichers.	
Autonomy					
Autonomy					
	After completion of	this module, participar	nts will be able to solve a technical	problem in teams of	approx. 2-4 perso
	independently includi	ng a presentation of the	results.		
Workload in Hours	Independent Study Ti	me 124, Study Time in L	ecture 56		
Credit points		,			
Course achievement		Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pr	rotocol for lecture series	
Examination	Presentation				
Examination duration and	Oral presentation + d	liscussion (30 min)			
scale					
Assignment for the	Biomedical Engineeri	ng: Specialisation Implar	ts and Endoprostheses: Elective Compul	sory	
Following Curricula	Biomedical Engineering	ng: Specialisation Artifici	al Organs and Regenerative Medicine: Co	ompulsory	
	Biomedical Engineering	ng: Specialisation Manag	ement and Business Administration: Elec	ctive Compulsory	
	Biomedical Engineeri	ng: Specialisation Medica	al Technology and Control Theory: Electiv	o Compulson	

Course L0347: Regenerative	Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
	The course deals with the application of biotechnological engineering principles for re-generation of human tissues. The main topics are "tissue engineering" for the generation of "artificial organs" such as cartilage, liver, blood vessel etc., and their applications: • Introduction (historical development, examples for medical and technical applications, commercial aspets) • Cell specific fundamentals (cell physiology, biochemistry, metabolism, special requirements for cell cultivation "in vitro") • Process specific fundamentals (requirements for culture systems, examples for reactor design, mathematical modelling, process and control strategies) • Examples for applications for clinical applications, drug testing and material testing The fundamentals will be presented by the lecturers. The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Course L1664: Lecture Tissu	e Engineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber),
	Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Courses						
Title			Тур	Hrs/wk	СР	
Robotics and Navigation in Medicir	ie (L0335)			Lecture	2	3
Robotics and Navigation in Medicir	ie (L0338)			Project Seminar	2	2
Robotics and Navigation in Medicir	e (L0336)			Recitation Section (small)	1	1
Module Responsible	Prof. Alexa	nder Schlae	efer			
Admission Requirements	None					
Recommended Previous Knowledge	principles of math (algebra_analysis/calculus)					
Educational Objectives	After taking	g part succe	essfully, students have	eached the following learning results		
Professional Competence						
	detail. Syst systems re	tems can b garding des	be evaluated with resp sign and limitations.	acking systems in clinical contexts and illu act to collision detection and safety and navigation systems and robotic systems for	regulations. Student	s can assess typic
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. The students can reflect their knowledge and document the results of their work. They can present the results in an appropria manner.					
Workload in Hours	Independer	nt Study Tir	me 110, Study Time in L	ecture 70		
Credit points	6					
Course achievement	Compulsory Yes Yes	Bonus 10 % 10 %	Form Written elaboration Presentation	Description		
Examination	Written exa	am				
Examination duration and	90 minutes	3				
scale	Computer !	Science: Sp	ecialisation II: Intelligen	ce Engineering: Elective Compulsory		
	computer.					
Assignment for the	-	Ingineering:	Specialisation Medical	Technology: Elective Compulsory		
Assignment for the	Electrical E			Technology: Elective Compulsory ipecialisation II. Electrical Engineering: Elect	ive Compulsory	
Assignment for the	Electrical E Internation Internation	nal Managen nal Managen	nent and Engineering: S nent and Engineering: S	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio		Compulsory
Assignment for the	Electrical E Internation Internation	nal Managen nal Managen	nent and Engineering: S nent and Engineering: S	pecialisation II. Electrical Engineering: Elect		Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni	nal Managen nal Managen ics: Speciali	nent and Engineering: S nent and Engineering: S sation Intelligent System	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio	otechnology: Elective	Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni Biomedical Biomedical	nal Managen nal Managen ics: Speciali I Engineerin I Engineerin	nent and Engineering: S nent and Engineering: S isation Intelligent Syste g: Specialisation Artifici g: Specialisation Implar	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elect its and Endoprostheses: Elective Compulsor	otechnology: Elective ive Compulsory y	Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni Biomedical Biomedical Biomedical	hal Managen hal Managen ics: Speciali I Engineerin I Engineerin I Engineerin	nent and Engineering: S nent and Engineering: S sation Intelligent Syster g: Specialisation Artifici g: Specialisation Implar g: Specialisation Medica	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elect its and Endoprostheses: Elective Compulsor al Technology and Control Theory: Elective C	otechnology: Elective ive Compulsory y Compulsory	Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni Biomedical Biomedical Biomedical Biomedical	nal Managen nal Managen ics: Speciali I Engineerin I Engineerin I Engineerin	nent and Engineering: S nent and Engineering: S sation Intelligent Syster g: Specialisation Artifici g: Specialisation Implar g: Specialisation Medic g: Specialisation Manag	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio ms and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elect its and Endoprostheses: Elective Compulsor al Technology and Control Theory: Elective C lement and Business Administration: Electiv	otechnology: Elective ive Compulsory y Compulsory e Compulsory	Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni Biomedical Biomedical Biomedical Biomedical Product De	nal Managen nal Managen ics: Speciali I Engineerin I Engineerin I Engineerin evelopment,	nent and Engineering: S nent and Engineering: S sation Intelligent Syster g: Specialisation Artifici g: Specialisation Implar g: Specialisation Medic g: Specialisation Manag Materials and Producti	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio ms and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elect its and Endoprostheses: Elective Compulsor al Technology and Control Theory: Elective C gement and Business Administration: Electiv on: Specialisation Product Development: Elec	otechnology: Elective ive Compulsory y Compulsory e Compulsory ective Compulsory	Compulsory
Assignment for the	Electrical E Internation Internation Mechatroni Biomedical Biomedical Biomedical Product De Product De	nal Managen nal Managen ics: Speciali I Engineerin I Engineerin I Engineerin I Engineerin evelopment,	nent and Engineering: S nent and Engineering: S sation Intelligent Syster g: Specialisation Artifici g: Specialisation Implar g: Specialisation Medic g: Specialisation Manac Materials and Producti Materials and Producti	pecialisation II. Electrical Engineering: Elect pecialisation II. Process Engineering and Bio ms and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elect ths and Endoprostheses: Elective Compulsor al Technology and Control Theory: Elective C mement and Business Administration: Electiv on: Specialisation Product Development: Ele on: Specialisation Production: Elective Comp	otechnology: Elective ive Compulsory y Compulsory e Compulsory ective Compulsory pulsory	Compulsory
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Course L0335: Robotics and	Navigation in Medicine
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	 kinematics calibration tracking systems navigation and image guidance motion compensation The seminar extends and complements the contents of the lecture with respect to recent research results.
Literature	Spong et al.: Robot Modeling and Control, 2005 Troccaz: Medical Robotics, 2012 Further literature will be given in the lecture.

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

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

Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Mec	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in Le	cture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artificia	Organs and Regenerative Medicine: (Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compu	ilsory	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elect	ive Compulsory	

Course L1963: Case Studies	Course L1963: Case Studies for Regenerative Medicine and Tissue Engineering		
Тур	Seminar		
Hrs/wk	3		
СР	6		
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42		
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock		
Language	DE		
Cycle	SoSe		
Content			
Literature			

Module M0634: Intro	duction	into Me	edical Technolog	gy and Syster	ns		
Courses							
Title					Тур	Hrs/wk	СР
Introduction into Medical Technolo	gy and Syste	ms (L0342)			Lecture	2	3
Introduction into Medical Technolo	gy and Syste	ms (L0343)			Project Seminar	2	2
Introduction into Medical Technolo	gy and Syste	ms (L1876)			Recitation Section (large)	1	1
Module Responsible	Prof. Alexa	nder Schla	aefer				
Admission Requirements	None						
Recommended Previous	principles	of math (a	lgebra, analysis/calculu	s)			
Knowledge							
	principles	of program	nming, R/Matlab				
Educational Objectives	After takin	g part suc	cessfully, students have	e reached the follow	ing learning results		
Professional Competence							
	The stude	nts can e	xplain principles of me	dical technology, i	ncluding imaging systems,	computer aided s	surgery, and medica
5					atory affairs and standards i		
Skills	The studer	nts are abl	e to evaluate systems a	ind medical devices	in the context of clinical app	olications.	
Personal Competence							
Social Competence	The studer	nts describ	e a problem in medical	technology as a pro	ject, and define tasks that a	re solved in a join	t effort.
		The students can reflect their knowledge and document the results of their work. They can present the results in an appropria					
Autonomy		nts can ref	flect their knowledge a	nd document the re	sults of their work. They ca	n present the resu	ults in an appropriate
	manner.						
Workload in Hours	Independe	nt Study T	ime 110, Study Time in	Lecture 70			
Credit points	6						
Course achievement	Compulsory	Bonus	Form	Description			
	Yes	10 %	Written elaboration				
	Yes	10 %	Presentation				
Examination	Written ex	am					
Examination duration and	90 minutes	5					
scale							
Assignment for the					pecialisation Biomedical Eng		ory
Following Curricula	-				eering: Elective Compulsory		
	-				ng Science: Elective Compul	sory	
			ualification: Elective Co	1			
		-	g: Core Qualification: El				
	-		Specialisation Biomedi				
					ecialisation Biomedical Engi		
	Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory						
			5 5 1		er Science: Elective Compuls	·	
				•	ring Sciences: Elective Com	-	
		-	•		generative Medicine: Elective	Compulsory	
Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory							
		-	•	•••	Control Theory: Elective Cor		
					ess Administration: Elective (Compulsory	
	Technoma	thematics	Specialisation III. Engir	neering Science: Ele	ctive Compulsory		

Course L0342: Introduction i	nto Medical Technology and Systems			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Alexander Schlaefer			
Language	DE			
Cycle	SoSe			
Content	- imaging systems			
	- computer aided surgery			
	- medical sensor systems			
	nedical information systems			
	egulatory affairs			
	- standard in medical technology			
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.			
Literature	Wird in der Veranstaltung bekannt gegeben.			

Course L0343: Introduction i	urse L0343: Introduction into Medical Technology and Systems			
Тур	Project Seminar			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Alexander Schlaefer			
Language				
Cycle	SoSe			
Content	e interlocking course			
Literature	See interlocking course			

Course L1876: Introduction i	nto Medical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonli	inear Dynamics			
Courses				
Title Nonlinear Dynamics (L0702)	Typ Hrs/wk CP Integrated Lecture 4 6			
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Calculus			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
-	 Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new to concepts. Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and to develop novel methods and procesures of Nonlinear Dynamics and the Nonlinear Dynamics and th			
Personal Competence		ocedure		
-	s Students can reach working results also in groups.			
Autonomy		mselves		
,	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination	Nritten exam			
Examination duration and scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory			
Following Curricula	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 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 Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

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

	conductor Technology			
Courses				
Title		Тур	Hrs/wk	СР
Semiconductor Technology (L0722 Semiconductor Technology (L0723		Lecture Practical Course	4	4 2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, material science and sen	iconductor devices		
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence Knowledge				
	Students are able			
	 to describe and to explain current fabrication tech 	niques for Si and GaAs substrates,		
	 to discuss in details the relevant fabrication semiconductor devices and integrated circuits and 	processes, process flows and t	he impact thereof o	n the fabrication
	 to present integrated process flows. 			
Skills				
	Students are capable			
	 to analyze the impact of process parameters on the second s	ne processing results,		
	 to select and to evaluate processes and 			
	 to develop process flows for the fabrication of sen 	niconductor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab ex of audience.	periments in team work as well as	to present and discus	ss the results in fro
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics	and Microsystems Technology: Elec	ctive Compulsory	
-	Biomedical Engineering: Specialisation Artificial Organ			
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsor	У	
	Biomedical Engineering: Specialisation Medical Techno	ology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Management a		e Compulsory	
	Microelectronics and Microsystems: Core Qualification	Elective Compulsory		

 Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation darr annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kind influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidatic GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kind temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technic APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vac evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxi and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique electroplating, improving resolution: excimer laser light source, immersion lithography, wet chemical etching: isotropic anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etc backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) 	urse L0722: Semiconducto	or Technology
cp 4 Workload in Hours Independent: Study Time 64, Study Time in Lecture 56 Lecture Prof. Hoc Khiem Trieu Language DE/Ell Cycle SoSe Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurites, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, h, indiffuences on growth rate, process technology and equipment teory, implantation profile, channeling, implantation dar annealing and equipment) Ovidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kin influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidatio GaAs) Deposition techniques (bubractive methods, photolithography, resist properties, printing techniques: high valexy gas phase, liquid phase, molecular beam gittary: CVD technice APCVD, LPCV, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high valexyparby, EVU techniques: printing techniques: inder technique electroplating, improving resolution innt, practical issues and equipment, additive methods: liftoff technique electroplating, impro	Тур	Lecture
Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Lecturer Pof. Hoc Khlem Trieu Language DEEN Cycle SoSe Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal. Miller Indices, crystal.lographic defects) Crystal fabrication (crystal pulling for 51 and GaAs: impurities, purification, Czochralski . Bridgeman and float zone proce Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dar annealing and equipment! Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation; treactions, kin influences on growth rate, process technology and equipment, andic oxidation, plasma oxidation, thermal oxidation (faks) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kin temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxi and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique electroplating, improving resolution imat, practical issues and equipment, additive methods: liftoff techni	Hrs/wk	4
Lecture Prof. Hoc Khiem Trieu Language DE/EN Cycte SoSe Context Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller Indices, crystallographic defacts) Crystal fabrication (crystal pulling for S) and GAAs: impurities, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by aloying, doping by diffusion: transport processes, doping profile, hi order affects and process technology, ion implantation: theory, implantation profile, channeling, implantation dar annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinn influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidati GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinn temperature dependence and equipment; patawa, gas phase, liquid phase, molecular beam epitaxy; CVD techniques: duptoring, resolution: extimer isser light source, immersion lithography and phase shift libography and phase shift libography, and packaging ischniques devaloration, internique ry etchniques; dr	CP	4
Language DE/EN Cycle SoSe Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurifies, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (crystal pulling for Si and GaAs: impurifies, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation, plasma oxidation; reactions, kin influences on growth rate, process technology and equipment, andic civitation, plasma oxidation, thermal oxidatio GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kin temperature dependence and equipment; epitaxy; gas phase, liquid phase, molecular beam epitaxy; CVD techniques: high vac evaporation, sputtering) structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxi and projection printing, resolution is exime last light source, immersion lithography, wet chemical etching: isotropic anistotropic, comer undercuring, compensation masks and ech stop techniques; dubtracting isotropic comer undercuring, compensation masks and ech stop techniques; dubta; isotropic anistotropic, comer undercuring, comerundercuring, andenshapa	Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Cycle SoSe Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impunities, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (process flow, specification, 50) Fabrication processes Doping (energy band diagram, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dar annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kin influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidatio (GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kine temperature dependence and equipment, gas phase, liquid phase, molecular beam epitasy; CVD techniques: high vac evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: indip vac evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: indip vac phase solution: excitomer, immersion lithography, wet chemical etching: isotropic anisotropic, corner undercuting, compensation masks and etch stop techniques; dry etching: blastropic anisotropic, corner undercuting, compensation masks and etch stop techniques; dry etching: isotropic	Lecturer	Prof. Hoc Khiem Trieu
Content Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dam annealing and equipment) Oxidation (silicon dixide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kim influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidatio (GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kin temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD technic APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vac evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, prox and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique electroplating, improving resolution: excimer last light source, immersion lithography, we themical etching: lostorpic, corner undercutting, compensation masks and ech stop techniques; dy etching: plasma enhanced etc backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipo	Language	DE/EN
 Introduction (historial view and trends in microelectronics) Basics in material science (semiconductor, crystal, Millin indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone proce Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hi order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dar annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kin influence on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidati GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kin temperature dependence and equipment; pitoxy: gas phase, liquid phase, molecular beam epitaxy; CVD technic APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vac evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxi and projection printing, resolution intit, practical issues and equipment, additive methods: liftoff technique electropiating, improving resolution: excimer laser light source, immersion lithography wet chenical etchning: isotropic anisotropic, corner underuting, compensation masks and etch at pot echniques: dry etching: plasma enhanced ecc backsputtering, Ion milling, chemical dry etching, RE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, elect	Cycle	SoSe
S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag	Content	 Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation - GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuu evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximit and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique ar electroplating, improving resolution limit, practical issues and equipment, additive methods: liftoff technique ar anisotropic, corner undercuting, compensation masks and etch stop techniques; dry etchnig: plasma enhanced etching backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact
U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag	Literature	
H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag		S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
		U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin		H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
		K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press		S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill		P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Course L0723: Semiconducto	ourse L0723: Semiconductor Technology		
Тур	Practical Course		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Hoc Khiem Trieu		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module Manual M.Sc. "Biomedical Engineering"

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	. Chudanta ann annlain humanaid mhata			
	 Students can explain humanoid robots. Students learn to apply basic control on 	neants for different tasks in humaneid re	batics	
	 Students learn to apply basic control co 	ncepts for unreferit tasks in numariou ro	idotics.	
Skills				
	 Students acquire knowledge about selection 		d on specified literature	
	 Students generalize developed results a 			
	 Students practice to prepare and give a 	presentation		
Personal Competence				
Social Competence				
	 Students are capable of developing solution 	tions in interdisciplinary teams and pres	ent them	
	They are able to provide appropriate fee	edback and handle constructive criticism	of their own results	
Autonomy				
,	 Students evaluate advantages and dr 	awbacks of different forms of presenta	tion for specific tasks	and select the be
	solution			
	 Students familiarize themselves with a 		and follow presentation	ns of other studen
	such that a scientific discussion develop	IS		
Workload in Hours	Independent Study Time 32, Study Time in Leo	ture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent System	ns and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: E	1 3		
	Biomedical Engineering: Specialisation Artificia	5 5	1 3	
	Biomedical Engineering: Specialisation Implan		•	
	Biomedical Engineering: Specialisation Medica			
	Biomedical Engineering: Specialisation Manage			
	Theoretical Mechanical Engineering: Technical			
	Theoretical Mechanical Engineering: Specialisa	tion Robotics and Computer Science: Ele	ective Compulsory	

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

Courses					
Title		Тур	Hrs/wk	СР	
Linear and Nonlinear System Ident		Lecture	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Classical control (frequency respo	unse root locus)			
Knowledge	 State space methods 				
	Discrete-time systems				
	 Linear algebra, singular value dec 	composition			
	Basic knowledge about stochastic				
	After taking part successfully, students h	nave reached the following learning results			
Professional Competence					
Knowledge	• Students can explain the general	I framework of the prediction error method	and its application to a	variety of linear a	
	nonlinear model structures			-	
	 They can explain how multilayer p 	perceptron networks are used to model nonlir	lear dynamics		
	They can explain how an approxir	mate predictive control scheme can be based	on neural network mode	els	
	• They can explain the idea of subs	an explain the idea of subspace identification and its relation to Kalman realisation theory			
<i></i>					
Skills	 Students are capable of applying 	g the predicition error method to the experi	mental identification of	linear and nonlin	
	models for dynamic systems				
	They are capable of implementing	g a nonlinear predictive control scheme based	l on a neural network mo	odel	
	 They are capable of applying subs 	space algorithms to the experimental identific	ation of linear models fo	or dynamic system	
	 They can do the above using stan 	dard software tools (including the Matlab Sys	tem Identification Toolb	ox)	
Personal Competence					
	Students can work in mixed groups on si	pecific problems to arrive at joint solutions.			
Social competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.			
Autonomy	Students are able to find required inform	nation in sources provided (lecture notes, lite	rature, software docume	entation) and use i	
	solve given problems.				
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28			
Credit points					
Course achievement					
Examination					
Examination duration and					
scale					
	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Electiv	e Compulsory		
-		Systems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Des				
		Artificial Organs and Regenerative Medicine: E	lective Compulsory		
	• • •	mplants and Endoprostheses: Elective Compu			
		ledical Technology and Control Theory: Comp			
	• • •	Aanagement and Business Administration: Ele			
	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Comp	oulsory		
	Theoretical Mechanical Engineering: Cor	o Qualification: Elective Compulson			

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

Courses				
Fitle		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658		Lecture	2	3 3
Optimal and Robust Control (L0659		Recitation Section (small)	Z	3
Module Responsible				
Admission Requirements	None			
Recommended Previous	Classical control (frequency response, root locu	s)		
Knowledge	State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence	First taking part succession, students have reached			
Knowledge				
5	 Students can explain the significance of the ma 			
	• They can explain the duality between optimal s			
	They can explain how the H2 and H-infinity north			
	 They can explain how an LQG design problem c They can explain how model upcertainty can be 			
	 They can explain how model uncertainty can b They can explain how - based on the small gai 			
	an uncertain plant.		arantee stability	
	 They understand how analysis and synthesis co 	nditions on feedback loops can be repre	esented as linear	matrix inequalit
	· · · · · · · · · · · · · · · · · · ·			
Skills	 Students are capable of designing and tuning L 	OG controllers for multivariable plant m	odels.	
	 They are capable of representing a H2 or H-infi 			nd of using stan
	software tools for solving it.	,		j.
	 They are capable of translating time and frequencies 	ency domain specifications for control	loops into const	raints on closed-
	sensitivity functions, and of carrying out a mixe	d-sensitivity design.		
	They are capable of constructing an LFT unce	rtainty model for an uncertain system	, and of designir	ng a mixed-objed
	robust controller.			
	 They are capable of formulating analysis and s 	ynthesis conditions as linear matrix ine	qualities (LMI), a	nd of using stand
	LMI-solvers for solving them.			
	 They can carry out all of the above using stands 	ard software tools (Matlab robust contro	l toolbox).	
Personal Competence				
Social Competence	Students can work in small groups on specific problem	is to arrive at joint solutions.		
Autonomy	Students are able to find required information in source	es provided (lecture notes, literature, s	oftware docume	ntation) and use
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points				
	None			
Examination				
Examination duration and scale	30 min			
-	Electrical Engineering: Specialisation Control and Powe		ulsory	
Following Curricula	Energy Systems: Core Qualification: Elective Compulse	,		
	Aircraft Systems Engineering: Specialisation Aircraft S Mechatronics: Specialisation Intelligent Systems and F			
	Mechatronics: Specialisation Intelligent Systems and P Mechatronics: Specialisation System Design: Elective			
	Biomedical Engineering: Specialisation Artificial Organ		Compulsory	
	Biomedical Engineering: Specialisation Artificial organ Biomedical Engineering: Specialisation Implants and E	-		
	Biomedical Engineering: Specialisation Medical Techno		pulsory	
	Biomedical Engineering: Specialisation Management a		-	
	Product Development, Materials and Production: Spec			
	Product Development, Materials and Production: Spec			
	Product Development, Materials and Production: Spec		-	
	Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualification	: Elective Compulsory		

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

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

Courses		
	Tun Hashula CD	
Title Marketing of Innovations (L2009)	TypHrs/wkCPLecture44	
PBL Marketing of Innovations (L086		
Module Responsible	Prof. Christian Lüthje	
Admission Requirements		
Recommended Previous		
Knowledge	Module International Business	
	Basic understanding of business administration principles (strategic planning, decision theory, project man	ageme
	international business)	abavi
	 Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Basics of Buying B- Unerstanding the differences beweetn B2B and B2C marketing 	siidvi
	 Understanding of the importance of managing innovation in global industrial markets 	
	Good English proficiency; presentation skills	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	Students will have gained a deep understanding of	
	 Specific characteristics in the marketing of innovative poroducts and services 	
	Approaches for analyzing the current market situation and the future market development	
	The gathering of information about future customer needs and requirements	
	Concepts and approaches to integrate lead users and their needs into product and service development processes	
	Approaches and tools for ensuring customer-orientation in the development of new products and innovative service	S
	Marketing mix elements that take into consideration the specific requirements and challenges of innovative proc	ucts
	services	
	 Pricing methods for new products and services 	
	 The organization of complex sales forces and personal selling 	
	 Communication concepts and instruments for new products and services 	
Skills	Based on the acquired knowledge students will be able to:	
	 Design and to evaluate decisions regarding marketing and innovation strategies 	
	Analyze markets by applying market and technology portfolios	
	Conduct forecasts and develop compelling scenarios as a basis for strategic planning	
	• Translate customer needs into concepts, prototypes and marketable offers and successfully apply advanced met	hods
	customer-oriented product and service development	
	 Use adequate methods to foster efficient diffusion of innovative products and services 	
	 Choose suitable pricing strategies and communication activities for innovations 	
	 Make strategic sales decisions for products and services (i.e. selection of sales channels) 	
	 Apply methods of sales force management (i.e. customer value analysis) 	
Personal Competence		
Social Competence	The students will be able to	
	have fruitful discussions and exchange arguments	
	 develop original results in a group present results in a clear and concise way 	
	carry out respectful team work	
Autonomy	The students will be able to	
Autonomy	The students will be able to	
	Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem	ı fielc
	 Consider proposed business actions in the field of marketing and reflect on them. 	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70	
Credit points		
Course achievement		
	Subject theoretical and practical work	
Examination duration and		
scale		
	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory	
Following Curricula	International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory	
2	Mechanical Engineering and Management: Specialisation Management: 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 Management and Business Administration: Compulsory	

Course L2009: Marketing of	Innovations
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
	Prof. Christian Lüthje
Language	
Cycle Content	I. Introduction
	 Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

Course L0862: PBL Marketing	g of Innovations
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1)
	forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation,
	managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will
	be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making wtihin a
	market simulation game.
Literature	

Courses					
Title		Тур	Hrs	/wk	СР
Applied Design Methodology in Mechatronics (L1523)		Lecture	2		2
Applied Design Methodology in Me	chatronics (L1524)	Project-/problem	-based Learning 3		4
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical des	sign or computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students ha	ve reached the following learning resu	lts		
Professional Competence					
Knowledge	Science-based working on interdisciplinary	v product design considering targeted a	application of specific	product	design technique
Chille					
SKIIIS	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application various product design techniques following theoretical aspects.				
	various product design techniques followin	ig theoretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with applicat		with applicatio		
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the design	gn and development process according	g to the target and top	pic of the	design
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-wo	ork			
scale					
Assignment for the	International Management and Engineerin	g: Specialisation II. Product Developme	ent and Production: El	ective Co	mpulsory
Following Curricula	International Management and Engineerin	g: Specialisation II. Mechatronics: Elect	ive Compulsory		
	Mechanical Engineering and Management	Specialisation Product Development a	nd Production: Election	ve Compu	ulsory
	Mechatronics: Specialisation System Desig	n: Elective Compulsory			
	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medici	ne: Elective Compulse	ory	
	Biomedical Engineering: Specialisation Imp	•			
	Biomedical Engineering: Specialisation Me				
	Biomedical Engineering: Specialisation Ma	•		-	
	Theoretical Mechanical Engineering: Speci			npulsory	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective	Compulsory		

Course L1523: Applied Desig	n Methodology in Mechatronics	
Тур	Lecture	
Hrs/wk	2	
СР		
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	 Systematic analysis and planning of the design process for products combining a multitude of disciplines Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics) Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,) Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making Value-analysis Derivation of architectures and architectural management Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) Project-execution methods (Scrum, Kanbaan,) Presentation-skills Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) Evaluation of selected methods at practical examples in small teams 	
Literature	 Definition folgt Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoder und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff 	

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

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame	ntals (L0841)	Lecture	2	3
Bioprocess Engineering- Fundamer	tals (L0842)	Recitation Section (large)	2	1
Bioprocess Engineering - Fundame	ntal Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "funda	mentals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have reac	ned the following learning results		
Professional Competence				
Knowledge	Students are able to describe the basic concepts enzymes and microorganisms, as well as to di rheology can be named and mass transport pro fundamental bioprocess management, sterilizatio	fferentiate different types of inhibition. T presses in bioreactors can be explained.	he parameters of The students are	of stoichiometry a
Skills	After successful completion of this module, studer	nts should be able to		
 describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding patient of the predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth fermentation process 				
	 analyze bioprocesses on basis of stoichiom distinguish between scale-up criteria for dil to compare them as well as to apply them i propose solutions to complicated biotechnom 	ferent bioreactors and bioprocesses (anaer to current biotechnical problem	obic, aerobic as	well as microaero
	 to explore new knowledge resources and to 	apply the newly gained contents		
	 identify scientific problems with concrete in 	dustrial use and to formulate solutions.		
	 to document and discuss their procedures a 	as well as results in a scientific manner		
Personal Competence				
Social Competence	After completion of this module participants shou take position to their own opinions and increase the			
Autonomy	y After completion of this module participants will be able to solve a technical problem in a team independently by organizing t workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lectur	e 84		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
course demovement	Yes 5 % Subject theoretical an			
	practical work			
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	General Engineering Science (German program, 7	semester): Specialisation Process Engineer	ing: Compulsory	
Following Curricula	General Engineering Science (German program, 7	semester): Specialisation Bioprocess Engin	eering: Compuls	ory
J	Bioprocess Engineering: Core Qualification: Comp			-
	General Engineering Science (English program, 7		ering: Compulso	ry
	General Engineering Science (English program, 7		• ·	-
	Biomedical Engineering: Specialisation Artificial O			
	Biomedical Engineering: Specialisation Implants a		-	
	Biomedical Engineering: Specialisation Medical Te		pulsory	
	Biomedical Engineering: Specialisation Manageme	•••		
	Technomathematics: Specialisation III. Engineerin			

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	 Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) Kinetic of subtrate consumption and product formation (Prof. Zeng) Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) Transport process in a bioreactor (Prof. Zeng) Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	 K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess En	igineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

Course L0843: Bioprocess En	ngineering - Fundamental Practical Course
Тур	Practical Course
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Courses				
Title Introduction to Anatomy (L0384)		Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof IIdo Schumacher	Lecture	2	5
Admission Requirements	None			
Recommended Previous	None			
Knowledge	None			
5	After taking part successfully, students have rea	bed the following learning results		
Professional Competence	The taking part succession, stadents have real			
	The students can describe basal structures and f The students can describe the basic macroscopy	÷	nusculoskeletal system.	
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; th can explain the relevance of structures and their functions in the context of widespread diseases.			
Personal Competence				
Social Competence	The students can participate in current discussio	ns in biomedical research and medic	ine on a professional level	
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqu the relevant knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lectu	re 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	General Engineering Science (German program,	7 semester): Specialisation Biomedie	cal Engineering: Compulso	ry
Following Curricula	General Engineering Science (German progra	m, 7 semester): Specialisation M	echanical Engineering, Fo	ocus Biomechan
	Compulsory			
	Data Science: Specialisation Medicine: Compulso	•		
	Electrical Engineering: Specialisation Medical Teo			
	Engineering Science: Specialisation Biomedical E			
	General Engineering Science (English program	n, 7 semester): Specialisation Mo	echanical Engineering, Fo	ocus Biomechan
	Compulsory General Engineering Science (English program, 7	competer): Specialization Piemodic	al Engineering: Compulsor	
	General Engineering Science (English program, 7	•		-
	Mechanical Engineering: Specialisation Biomecha		ar Engineering. compulsor	3
	Biomedical Engineering: Specialisation Medical T		ive Compulsory	
	Biomedical Engineering: Specialisation Managem	•••		
	Biomedical Engineering: Specialisation Artificial C			
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Comp	ulsory	

Course L0384: Introduction t	o Anatomy			
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study	r Time 62, Study Time in Lecture 28		
Lecturer	Prof. Tobias Lange			
Language				
Cycle	SoSe			
Content	General Anatomy	V		
	1 st week:	The Eucaryote Cell		
	2 nd week:	The Tissues		
	3 rd week:	Cell Cycle, Basics in Development		
	4 th week:	Musculoskeletal System		
	5 th week:	Cardiovascular System		
	6 th week:	Respiratory System		
	7 th week:	Genito-urinary System		
	8 th week:	Immune system		
	9 th week:	Digestive System I		
	10 th week:	Digestive System II		
	11 th week:	Endocrine System		
	12 th week:	Nervous System		
	13 th week:	Exam		
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016		

Courses				
Title		Тур	Hrs/wk	СР
Introduction to Physiology (L0385)		Lecture	2	3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	The students can			
	 describe the basics of the energy metabolism; 			
	 describe physiological relations in selected fields of m 	nuscle, heart/circulation,	neuro- and sensory physiol	logy.
Cl://-				
SKIIIS	The students can describe the effects of basic bodily function of forces and vital functions) and relate them to similar tech		in and processing of inform	iation, developme
Personal Competence		inical systems.		
	The students can conduct discussions in research and medi	rine on a technical level		
Social competence	The students can find solutions to problems in the field of pl		and metrological	
	······································	.,,	j	
Autonomy	The students can derive answers to questions arising in the	ne course and other phy	siological areas, using tec	hnical literature,
	themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedie	cal Engineering: Compulsor	ry
Following Curricula	General Engineering Science (German program, 7 sem	ester): Specialisation M	echanical Engineering, Fo	ocus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory			
	Electrical Engineering: Specialisation Medical Technology: E			
	Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 seme		echanical Engineering Ec	ocus Biomechani
	Compulsory	stery. specialisation in	centrical Engineering, re	bioincentain
	General Engineering Science (English program, 7 semester)	: Specialisation Biomedic	al Engineering: Compulson	v
	General Engineering Science (English program, 7 semester)	: Specialisation Biomedic	al Engineering: Elective Co	mpulsory
	Mechanical Engineering: Specialisation Biomechanics: Comp			
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: El	ective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine:	Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopr	ostheses: Elective Comp	ulsory	
	Technomathematics: Specialisation III. Engineering Science:			

Course L0385: Introduction t	Course L0385: Introduction to Physiology	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Gerhard Engler	
Language	DE	
Cycle	SoSe	
Content		
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme	
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier	

ourses				
itle		Тур	Hrs/wk	СР
ntroduction to Radiology and Radi	ation Therapy (L0383)	Lecture	2	3
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous	None			
Knowledge	After taking part successfully, students have reas	had the following learning results		
Professional Competence	After taking part successfully, students have reac	lied the following learning results		
Knowledge	Therapy			
	The students can distinguish different types of cu	rrently used equipment with respect	to its use in radiation the	erapy.
	The students can explain treatment plans used in	radiation therapy in interdisciplinary	v contexts (e.g. surgery,	nternal medicine)
	The students can describe the patients' pas	sage from their initial admittance	e through to follow-up	care.
	Diagnostics			
	The students can illustrate the technical base co well as sectional imaging techniques (CT, MRT, US		cluding angiography and	d mammography,
	The students can explain the diagnostic as well a techniques.	s therapeutic use of imaging technic	ques, as well as the tech	inical basis for the
	The students can choose the right treatment met	nod depending on the patient's clinic	al history and needs.	
	The student can explain the influence of technical	errors on the imaging techniques.		
	The student can draw the right conclusions based		or the error protocol	
		on the images diagnostic indings o	in the error protocol.	
Skills	Therapy The students can distinguish curative and palliativ	e situations and motivate why they	came to that conclusion.	
	The students can develop adequate therapy conc		logical aspects.	
	The students can use the therapeutic principle (ef	fects vs adverse effects)		
	The students can distinguish different kinds of tumor) and choose the energy needed in that situ		depending on the situa	tion (location of
	The student can assess what an individual psy- groups, self-help groups, social services, psycho-		e.g. follow-up treatment	, sports, social h
	Diagnostics			
	The students can suggest solutions for repairs of	maging instrumentation after having	g done error analyses.	
	The students can classify results of imaging tec anatomy, pathology and pathophysiology.	hniques according to different grou	ps of diseases based or	n their knowledge
Personal Competence				
Social Competence	The students can assess the special social situation. The students are aware of the special, often f measures and can meet them appropriately.			
Autonomy	The students can apply their new knowledge and The students can introduce younger students to t			
	The students are able to access anatomical know and acquire the relevant knowledge themselves.	ledge by themselves, can participat	te competently in conve	rsations on the to
Workload in Hours	Independent Study Time 62, Study Time in Lectur	e 28		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale Assignment for the	General Engineering Science (German program, 7	semester). Specialisation Biomedica	al Engineering: Compulse	irv
-	General Engineering Science (German program, 7 General Engineering Science (German program			-
	Compulsory		-	
	Data Science: Specialisation Medicine: Compulsor			
	Electrical Engineering: Specialisation Medical Tech Engineering Science: Specialisation Biomedical Er			
	General Engineering Science (English program Compulsory		chanical Engineering, F	ocus Biomechan

Module Manual M.Sc. "Biomedical Engineering"

General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introduction	to Radiology and Radiation Therapy		
Тур	Lecture		
Hrs/wk	2		
СР			
	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring		
Cycle			
Content	he students will be given an understanding of the technological possibilities in the field of medical imaging, iterventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the ourse have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. homas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, thich determine a predefined sequence in their respective departments		
Literature	 "Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999 		
	• "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –		
	4. Auflage - Verlag Urban & Fischer – erschienen 02.03.2006		
	ISBN: 978-3-437-23960-1		
	"Strahlentherapie und Onkologie für MTA-R" von R. Sauer –		
	5. Auflage 2003 - Verlag Urban & Schwarzenberg – erschienen 08.12.2009		
	ISBN: 978-3-437-47501-6		
	 "Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus- 		
	8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012		
	ISBN: 978-3-13-567708-8		
	• "Der Körper des Menschen " von A. Faller u. M. Schünke -		
	16. Auflage 2004 – Georg Thieme Verlag – erschienen 18.07.2012		
	ISBN: 978-3-13-329716-5		
	"Praxismanual Strahlentherapie" von Stöver / Feyer –		
	1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000		

Courses		
Title	Typ Hrs/wk CP	
Experimental Methods in Biomecha	anics (L0377) Lecture 2 3	
Module Responsible	Prof. Michael Morlock	
Admission Requirements	None	
Recommended Previous	It is recommended to participate in "Implantate und Frakturheilung" before attending "Experimentelle Methoden".	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.	
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.	
	The students can describe different measurement techniques for forces and movements, and choose the adequate technic	ue foi
	given task.	
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.	
Personal Competence		
Social Competence	The students can, in groups, solve basic experimental tasks.	
Autonomy	The students can, in groups, solve basic experimental tasks.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	3	
Course achievement	None	
Examination	Written exam	
Examination duration and	90 min	
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biome	chani
Following Curricula	Compulsory	
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biome	chani
	Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: 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 Management and Business Administration: Elective Compulsory	
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory	

Course L0377: Experimental	rse L0377: Experimental Methods in Biomechanics	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content		
Literature	Wird in der Veranstaltung bekannt gegeben	

Courses				
Title		T	Une fools	СР
Artificial Joint Replacement (L1306)		Typ Lecture	Hrs/wk	3
Module Responsible				
Admission Requirements				
	Basic knowledge of orthopedic and surgic	al techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students can name the different kind	s of artificial limbs.		
CL 111	-			
SKIIIS	The students can explain the advantages	and disadvantages of different kinds of end	loprotneses.	
Personal Competence				
Social Competence	The students are able to discuss issues re	lated to endoprothese with student mates a	and the teachers.	
Autonomy	The students are able to acquire informat	ion on their own. They can also judge the ir	formation with respect to	its credibility
Autonomy	The statents are usic to acquire informat	ion on their own. They can also judge the in	ionnation with respect to	its creationity.
Workload in Hours	Independent Study Time 62, Study Time i	n Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
-	• •	ng: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano an			
	• • •	tificial Organs and Regenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Ele	ective Compulsory	
	Orientierungsstudium: Core Qualification:	Elective Compulsory		
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Spec	ialisation Bio- and Medical Technology: Elec	tive Compulsory	

Course L1306: Artificial Joint	Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)
Literature	Literatur:
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.
	Sobotta und Netter für Anatomie der Gelenke

Courses					
Title Feedback Control in Medical Techn	alagy (1.0664)	Typ Lecture	Hrs/wk 2	CP 3	
Module Responsible		Locard	-	5	
Admission Requirements					
•	Basics in Control, Basics in Physiology				
Knowledge	,				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results			
Professional Competence					
Knowledge					
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system example in for anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or illustrated. The operation of simple equivalent circuits will be discussed.				
Skills	Application of modeling, identification, control technology in the field of medical technology.				
Personal Competence					
Social Competence	Students can develop solutions to specifi	c problems in small groups and present their	results		
Autonomy	y Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form consistent whole.				
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28			
Credit points					
Course achievement	None				
Examination	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Med	lical Technology: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Cor	trol and Power Systems Engineering: Elective	e Compulsory		
		nplants and Endoprostheses: Elective Compu	-		
	• • •	tificial Organs and Regenerative Medicine: E			
		anagement and Business Administration: Ele			
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Comp	ulsory		

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

Courses				
			11	
Title	Typ		Hrs/wk	CP
Advanced Topics in Control (L0661) Advanced Topics in Control (L0662)		ion (small)	2 2	3 3
		ion (smail)	Z	5
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning rest	ults		
Professional Competence				
Knowledge	 Students can explain the advantages and shortcomings of the classical g They can explain the representation of nonlinear systems in the form of o They can explain how stability and performance conditions for LPV system They can explain how gridding techniques can be used to solve analysis a They are familiar with polytopic and LFT representations of LPV system associated with each of these model structures Students can explain how graph theoretic concepts are used to representations They can explain the convergence properties of first order consensus processes They can explain analysis and synthesis conditions for formation control is Students can explain the state space representation of spatially invariant to an actuator/sensor array They can explain (in outline) the extension of the bounded real lemminiation of the state space representation of the state lemminiation of the state space representation of the state lemminiation of the state space representation of the state lemminiation of the state space representation of the state lemminiation of the state space representation of the state lemminiation of the state space representation of the state lemminiation of the state space representation space space space space s	quasi-LPV system ms can be formu and synthesis pro- ems and some resent the comm otocols loops involving e t distributed syst	is lated as LMI cc oblems for LPV of the basic s nunication top wither LTI or LPV tems that are o	systems synthesis techniqu ology of multiage / agent models discretized accordi
Skills	 synthesis conditions for distributed controllers Students are capable of constructing LPV models of nonlinear plants scheduled controllers; they can do this using polytopic, LFT or general LP They are able to use standard software tools (Matlab robust control toolb Students are able to design distributed formation controllers for groups Matlab tools provided Students are able to design distributed controllers for spatially interconnection. 	vV models vox) for these tas	ks either LTI or L	.PV dynamics, usi
Deveenal Compotence				
Personal Competence	Students can work in small groups and arrive at initiation .			
	Students can work in small groups and arrive at joint results.			
Autonomy	Students are able to find required information in sources provided (lecture note solve given problems.	s, literature, sofi	tware documer	ntation) and use it
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination				
Examination duration and	30 min			
scale				
	Electrical Engineering: Specialisation Control and Power Systems Engineering: E	lective Compuls	ory	
Assignment for the	Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compuls	ory		
Assignment for the Following Curricula		-		
-		ory		
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls	ory		
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory		1	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elec		/	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory	ctive Compulsory	/	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compuls	ctive Compulsory	/	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compuls Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Comp	ctive Compulsory sory Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compuls Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective C Biomedical Engineering: Specialisation Medical Technology and Control Theory:	ctive Compulsory sory Compulsory Elective Compul	lsory	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compuls Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective C Biomedical Engineering: Specialisation Medical Technology and Control Theory: Biomedical Engineering: Specialisation Management and Business Administration	ctive Compulsory sory Compulsory Elective Compul on: Elective Comp	lsory pulsory	
-	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compuls Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compuls Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective C Biomedical Engineering: Specialisation Medical Technology and Control Theory:	ctive Compulsory sory Compulsory Elective Compul on: Elective Comp	lsory pulsory	

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

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

Courses						
Title			Тур		Hrs/wk	СР
Bioelectromagnetics: Principles and	d Applications (L0371)		Lecture		3	5
Bioelectromagnetics: Principles and	d Applications (L0373)		Recitation Sect	ion (small)	2	1
Module Responsible	Prof. Christian Schuste	r				
Admission Requirements	None					
Recommended Previous Knowledge	Basic principles of phys	sics				
Educational Objectives	After taking part succe	ssfully, students have read	hed the following learning res	ults		
Professional Competence						
Knowledge	of electromagnetic fiel them corresponding to techniques for charact	lds in biological tissue. The owner the second s	ships, and methods of bioelec ey can define and exemplify t cy of the fields. They can giv tic fields in practical applicati medical technology.	he most impo ve an overviev	rtant physical ph w over measure	nenomena and ord ment and numeric
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make a appropriate choice.					
Personal Competence Social Competence	Students are able to w English (e.g. during sm	• •	elated tasks in small groups. T	They are able	to present their	results effectively
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content o other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.					
Workload in Hours	Independent Study Tim	ne 110, Study Time in Lecti	ure 70			
Credit points	6					
Course achievement	Compulsory Bonus Yes None	Form Presentation	Description			
Examination	Oral exam					
Examination duration and scale	45 min					
Assignment for the Following Curricula	Electrical Engineering: International Managem Biomedical Engineering Biomedical Engineering Biomedical Engineering	Specialisation Medical Tec nent and Engineering: Spec g: Specialisation Artificial C g: Specialisation Managem g: Specialisation Medical Te	Engineering, Optics, and Electr hnology: Elective Compulsory ialisation II. Electrical Enginee rgans and Regenerative Medic ent and Business Administratic echnology and Control Theory: and Endoprostheses: Elective C	ring: Elective C ine: Elective C on: Elective Co Elective Comp	Compulsory Compulsory mpulsory	ive Compulsory

Тур	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	
Cycle	WiSe
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Course L0373: Bioelectromag	urse L0373: Bioelectromagnetics: Principles and Applications		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Christian Schuster		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Specialization Management and Business Administration

Module M0623: Intelli	aont Systems i	n Modicino			
Module M0025. Intelli	igent systems i	n Medicine			
Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L03			Lecture	2	3
Intelligent Systems in Medicine (LO			Project Seminar	2	2
Intelligent Systems in Medicine (LO			Recitation Section (small)	1	1
Module Responsible		eter			
	None				
Recommended Previous Knowledge	 principles of mage 	ath (algebra, analysis/calcul	us)		
Kilowieuge	 principles of store 	ochastics			
	 principles of pr 	ogramming, Java/C++ and F	R/Matlab		
	 advanced prog 	ramming skills			
Educational Objectives	After taking part succ	essfully, students have reac	hed the following learning results		
Professional Competence					
Knowledge	The students are able	to analyze and solve clinic	al treatment planning and decision su	oport problems using	methods for search,
	optimization, and plan	ning. They are able to expl	ain methods for classification and their	respective advantage	es and disadvantages
	in clinical contexts. Th	e students can compare di	fferent methods for representing medic	al knowledge. They o	an evaluate methods
	in the context of clini	cal data and explain challe	nges due to the clinical nature of the d	ata and its acquisitio	on and due to privacy
	and safety requireme	nts.			
Skills	The students can give	e reasons for selecting and	adapting methods for classification, re	gression, and predict	tion. They can assess
			aluate the implemented methods.		-
Personal Competence	The students discuss				
Social Competence	The students discuss	the results of other groups,	provide helpful feedback and can incoo	rporate reedback into	their work.
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate				
	manner.				
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
	6	· ·			
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination					
	90 minutes				
scale					
•		-	ngineering: Elective Compulsory		
Following Curricula		•	hnology: Elective Compulsory		
			and Robotics: Elective Compulsory rgans and Regenerative Medicine: Elect	ive Compulsory	
			nd Endoprostheses: Elective Compulsor		
	÷		echnology and Control Theory: Elective	-	
	5	5 1	5,		
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				
			n Bio- and Medical Technology: Elective	-	

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

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

Course L0333: Intelligent Sy	irse 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		

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		T	Hara (anda	СР
Nature's Hierarchical Materials (L1)		Typ Seminar	Hrs/wk 2	3
	nas, and Electromagnetic Compatibility (L1669)	Lecture	2	3
-	has, and Electromagnetic Compatibility (L1887)	Recitation Section (small)	2	2
Development and Regulatory Appr		Lecture	2	3
Experimental Methods for the Char	-	Lecture	2	3
Numerical Methods in Biomechanic		Seminar	2	3
Seminar Biomedical Engineering (L		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management a	and Business Administration: Elective Co	mpulsory	

Course L1663: Nature's Hierarchical Materials		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and		
scale		
Lecturer	Prof. Gerold Schneider	
Language	EN	
Cycle	WiSe	
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc.This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.	
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications	

Course L1669: Introduction t	to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics:
	 Fundamental properties and phenomena of electrical circuits Steady-state sinusoidal analysis of electrical circuits Fundamental properties and phenomena of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves Useful microwave network parameters Transmission lines and basic results from transmission line theory Plane wave propagation, superposition, reflection and refraction General theory of waveguides Most important types of waveguides and their properties Radiation and basic antenna parameters Numerical techniques and CAD tools for waveguide and antenna design Fundamentals of Electromagnetic Compatibility Coupling mechanisms and countermeasures Shielding, grounding, filtering Standards and regulations EMC measurement techniques
Literature	 Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) D. M. Pozar, "Microwave Engineering", Wiley (2011) Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Roman Nassutt	
Language	DE	
Cycle	WiSe	
Content		
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html 	

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 	
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009	

ourse L1890: Seminar Biomedical Engineering		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

Course L1130: Six Sigma	
Тур	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

Тур	Lecture
Hrs/wk	
· · · · · · · · · · · · · · · · · · ·	4
CP	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale Lecturer	Prof. Michael Schlüter
Language	
Cycle	Wise
Content	Differential equations for momentum-, heat and mass transfer
	Examples for simplifications of the Navier-Stokes Equations
	Unsteady momentum transfer
	Free shear layer, turbulence and free jets
	 Flow around particles - Solids Process Engineering
	 Coupling of momentum and heat transfer - Thermal Process Engineering
	Rheology – Bioprocess Engineering
	 Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering
	Flow threw porous structures - heterogeneous catalysis
	 Pumps and turbines - Energy- and Environmental Process Engineering
	Wind- and Wave-Turbines - Renewable Energy
	Introduction into Computational Fluid Dynamics
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.
	 Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg
	2006.
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunger
	Springer Verlag, Berlin, Heidelberg, New York, 2006.
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW Fachverlage GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner GWV Fachverlage GmbH, Wiesbaden, 2009.
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.
	 Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe Verlag, Berlin, Heidelberg, 2008.
	12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simul	ation
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module Manual M.Sc. "Biomedical Engineering"

Course L0379: Ceramics Tech	nnology				
Тур	Lecture				
Hrs/wk	2				
CP	3				
Workload in Hours	Independent Study Time 62, Stu	udy Time in Lecture 28			
Examination Form	Klausur				
Examination duration and	90 Minuten				
scale					
Lecturer	Dr. Rolf Janßen	•			
Language					
Cycle	WiSe				
Content					
Literature	ASM Engineering Materials Hand	Ceramics", John Wiley & Sons, New York, 1975 dbook Vol.4 "Ceramics and Glasses", 1991 nic Engineering", Marcel Decker, New York, 1992			
	Skript zur Vorlesung				

Courses						
Title		Тур	Hrs/wk	СР		
ntelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4		
ntelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small)	2	2		
Module Responsible	Rainer Marrone					
Admission Requirements	None					
	Vectors, matrices, Calculus					
Knowledge						
	After taking part successfully, students have	e reached the following learning results				
Professional Competence						
Kilowieuge	(goals, utilities, environments). They can de	, define intelligence in terms of rational behav escribe the main features of environments. The plems and algorithms for solving these proble	notion of adversar	rial agent cooperat		
	world scenarios, students can summarize h	ow Bayesian networks can be employed as a l	knowledge represer	ntation and reason		
		In addition, students can define decision maki	• ·			
		the state of the environment. In this contex				
	solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving					
		nation problems and decision making in a mult				
		protocol, and mechanism design techniques.	a ugene setting in t	erni or amerene cy		
Skills		architecture for concrete agent application so				
	students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply					
		agent scenarios. For simple and complex dec				
		. In multi-agent situations students will apply t	-			
		decision making students will apply different v		•		
	the results.					
Personal Competence						
Social Competence	Students are able to discuss their solutions	to problems with others. They communicate in	English			
Autonomy	Students are able of checking their understa	anding of complex concepts by solving varaints	of concrete proble	ms		
	Independent Study Time 124, Study Time in	Lecture 56				
Credit points						
Course achievement Examination						
Examination duration and						
scale	90 minutes					
	Computer Science: Specialisation II: Intellige	ence Engineering: Elective Compulsory				
-		: Specialisation II. Information Technology: Elec	tive Compulsory			
	Mechatronics: Technical Complementary Co	ourse: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Syst	ems and Robotics: Elective Compulsory				
	Biomedical Engineering: Specialisation Artif	icial Organs and Regenerative Medicine: Electiv	e Compulsory			
	• • • •	ants and Endoprostheses: Elective Compulsory				
	• • •	ical Technology and Control Theory: Elective Co				
		agement and Business Administration: Elective				
	meoretical Mechanical Engineering: Techni	cal Complementary Course: Elective Compulso	У			
	Theoretical Mechanical Engineering, Specia	lisation Robotics and Computer Science: Electiv	e Compulsory			

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

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

Module M0746: Micro	system Engine	ering				
Courses						
Title				Тур	Hrs/wk	СР
Microsystem Engineering (L0680)				Lecture	2	4
Microsystem Engineering (L0682)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper					
Admission Requirements	None					
Recommended Previous	Basic courses in phys	ics, mathematics	and electric engineering			
Knowledge						
Educational Objectives	After taking part succ	essfully, students	have reached the followi	ing learning results		
Professional Competence						
Knowledge	The students know a	bout the most in	nportant technologies an	d materials of MEMS as well as	their applica	tions in sensors and
	actuators.					
SKIIIS		analyze and de	escribe the functional be	ehaviour of MEMS components	and to evaluate	ate the potential of
	microsystems.					
Personal Competence						
Social Competence	Students are able to s	solve specific prob	plems alone or in a group	and to present the results accord	dingly.	
Autonomy		acquire particular	r knowledge using specia	lized literature and to integrate	and associate	this knowledge with
	other fields.					
Workload in Hours	Independent Study Ti	me 124, Study Tir	me in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation				
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	Electrical Engineering	: Core Qualificatio	on: Compulsory			
Following Curricula	International Manage	ment and Enginee	ering: Specialisation II. Ele	ectrical Engineering: Elective Con	npulsory	
	International Manage	ment and Enginee	ering: Specialisation II. Me	echatronics: Elective Compulsory		
	Mechanical Engineeri	ng and Manageme	ent: Specialisation Mecha	tronics: Elective Compulsory		
	Mechatronics: Special	lisation System De	esign: Elective Compulsor	ry		
	Biomedical Engineering	ng: Specialisation	Artificial Organs and Reg	enerative Medicine: Elective Con	npulsory	
	-	•		eses: Elective Compulsory		
	-	•	•••	Control Theory: Elective Compuls		
	-			ss Administration: Elective Comp	oulsory	
		-	re Qualification: Elective			
		• •		Course: Elective Compulsory		
	Theoretical Mechanic	al Engineering: Sp	pecialisation Bio- and Med	lical Technology: Elective Compu	lsory	

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

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibra	ion Theory and develop them fur	ther.	
Skills	Students are able to denote methods of Vibration Theory	and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks	in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
-	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisatio	. II. Machatropics: Elective Comp	ulcon	
Following Curricula	Mechanical Engineering and Management: Specialisation			
	Mechatronics: Core Qualification: Compulsory	Mechatronics. Elective compuise	n y	
	Biomedical Engineering: Specialisation Artificial Organs a	nd Regenerative Medicine: Electiv	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and End	•		
	Biomedical Engineering: Specialisation Medical Technolog			
	Biomedical Engineering: Specialisation Management and			
	Product Development, Materials and Production: Core Qu	alification: Compulsory		
	Naval Architecture and Ocean Engineering: Core Qualifica	tion: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Compleme	ntary Course: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Core Qualification: E	ective Compulsory		

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

2				
Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291) Finite Element Methods (L0804)		Lecture Recitation Section (large)	2 2	3 3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
•	Mechanics I (Statics, Mechanics of Materials) and Mec	hanics II (Hydrostatics, Kinematics, Dyna	amics)	
Knowledge	Mathematics I, II, III (in particular differential equation			
		the felle free landstand and he		
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence	The students persons on in depth knowledge regard	ding the derivation of the finite clame	at mathed and	ara abla ta giva
Knowledge	The students possess an in-depth knowledge regar overview of the theoretical and methodical basis of th		int method and	are able to give
		le method.		
Skills	The students are capable to handle engineering pro-	plems by formulating suitable finite eler	nents, assemblin	g the correspond
	system matrices, and solving the resulting system of	equations.		
Personal Competence				
	Students can work in small groups on specific probler	as to arrive at joint solutions		
social competence	stadents can work in small groups on specific problem			
Autonomy	The students are able to independently solve chall	lenging computational problems and d	evelop own finit	e element routir
	Problems can be identified and the results are critical	ly scrutinized.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement		scription		
	No 20 % Midterm			
Examination				
Examination duration and	120 min			
scale				
-	Civil Engineering: Core Qualification: Compulsory			
Following Curricula	Energy Systems: Core Qualification: Elective Computer	,		
	Aircraft Systems Engineering: Specialisation Aircraft S Aircraft Systems Engineering: Specialisation Aircraft S			
	Aircraft Systems Engineering: Specialisation Aircraft	, , ,		
	Aircraft Systems Engineering: Specialisation Air Trans			
	International Management and Engineering: Specialis			
	International Management and Engineering: Specialis		-	
	International Management and Engineering: Specialis			ompulsory
	International Management and Engineering: Specialis	ation II. Product Development and Produ	ction: Elective Co	mpulsory
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective (Compulsory	
	Product Development, Materials and Production: Core			
	Technomathematics: Specialisation III. Engineering So			
	Technomathematics: Specialisation III. Engineering So	ience: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualificatio			

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

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

Courses						
Courses				-	11	
Title Microsystems Technology (L0724)				Typ Lecture	Hrs/wk	CP 4
Microsystems Technology (L0725)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous	Basics in physics, che	mistry, mechanics and s	semiconductor techn	ology		
Knowledge						
	After taking part succ	essfully, students have	reached the following	g learning results		
Professional Competence	Students are able					
Knowieage	Students are able					
				or microstructures and especia of in more complex systems	Illy methods f	for the fabrication
	• to explain in deta	ils operation principles o	of microsensors and	microactuators and		
	 to discuss the po 	tential and limitation of	microsystems in app	lication.		
Skills	Students are capable					
	to analyze the feasibility of microsystems,					
	 to develop process flows for the fabrication of microstructures and 					
				5 and		
	 to apply them. 					
Personal Competence Social Competence						
	Students are able to of audience.	prepare and perform the	eir lab experiments ir	n team work as well as to prese	ent and discus	ss the results in fro
Autonomy	None					
Workload in Hours	Independent Study Ti	me 124, Study Time in I	Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus Yes None	Form Subject theoretical practical work		führen in Kleingruppen ein La d diskutiert die Theorie sowie o nten Kurs.		
Examination	Oral exam					
Examination duration and	30 min					
scale	Electrical Engineers'	Coocialization Name	stropics and Misse	retome Tochnology, Election Co	mulcon	
-		: Specialisation Nanoele : Specialisation Medical		vstems Technology: Elective Co e Compulsory	привогу	
ytulu		•	•••	hatronics: Elective Compulsory		
	-			nerative Medicine: Elective Com		
	-			ses: Elective Compulsory		
	-	•		ontrol Theory: Elective Compuls	-	
	DIOMEQUCAL ENGINEERI	ng. specialisation Mahag	yemenic and Business	Administration: Elective Comp	uisuiy	

Course L0724: Microsystems	Technology
-	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, np injunction, NTC and PTC; thermal anemometer, mass flow sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; explicate magnetometer) Magnetic Sensors (galvanomagnetic sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor; Lambda probe, MOSFET gas sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfiluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropu
	 stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding.
	TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Course L0725: Microsystems	urse L0725: Microsystems Technology	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hoc Khiem Trieu	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Courses					
Title		Туј	р	Hrs/wk	СР
Technology Management (L0849)	(10070)		ject-/problem-based Learning	3	3
Technology Management Seminar (Pro	ject-/problem-based Learning	2	3
-	Prof. Cornelius Herstatt				
Admission Requirements					
Recommended Previous Knowledge	Bachelor knowledge in business managen	nent			
-	After taking part successfully, students ha	ave reached the following le			
Professional Competence	Arter taking part successiony, students ha	ave reached the following le	saming results		
	Students will gain deep insights into:				
Kilowicage	Statenes win gain deep insignes into.				
	International R&D-Management				
	Technology Timing Strategies				
	 Technology Strategies and L 				
	Technology Intelligence and Technology Reterior	Planning			
	 Technology Portfolio Management Technology Portfolio Method 	lology			
	 Technology Acquisition and 				
	 IP Management 	Explored for			
	Organizing Technology Developme	ent			
	 Technology Organization & I 	Management			
	 Technology Funding & Contr 	rolling			
Skills	The course aims to:				
	 Develop an understanding of the in 	mortance of Technology M	anagement - on a national a	s well as inter	national level
	Equip students with an underst				
	organizational and process-related		ienes of ieennology inun	agement (se	acegie, operation
	 Foster a strategic orientation to pr 		nnovation process as well as	Technology	Management and
	importance for corporate strategy	-	·		-
	Clarify activities of Technology Mar	nagement (e.g. technology	sourcing, maintenance and ϵ	exploitation)	
	Strengthen essential communication	ion skills and a basic unde	erstanding of managerial, o	organizational	and financial issu
	concerning Technology-, Innovation	n- and R&D-management. F	urther topics to be discussed	d include:	
	 Basic concepts, models and tools, r 	relevant to the managemen	at of technology R&D and in	novation	
	 Innovation as a process (steps, acti 		it of teermology, neb and m	novacion	
Personal Competence					
Social Competence	 Interact within a team 				
	 Raise awareness for globabl issues 				
	5				
Autonomy	Gain access to knowledge sources				
	Discuss recent research debates in	the context of Technology	and Innovation Managemen	t	
	Develop presentation skills				
	 Discussion of international cases in 	n R&D-Management			
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the	Global Innovation Management: Core Qua	alification: Compulsory			
Following Curricula	International Management and Engineerir	ng: Specialisation I. Elective	s Management: Elective Con	npulsory	
	Mechanical Engineering and Management	t: Specialisation Manageme	nt: Elective Compulsory		
	Biomedical Engineering: Specialisation Ar			npulsory	
	Biomedical Engineering: Specialisation Im				
	Biomedical Engineering: Specialisation Me	edical Technology and Cont	rol Theory: Elective Compuls	sory	

Course L0849: Technology M	lanagement
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	The role of technology for the competitive advantage of the firm and industries; Basic concepts, models and tools for the management of technology; managerial decision making regarding the identification, selection and protection of technology (make or buy, keep or sell, current and future technologies). Theories, practical examples (cases), lectures, interactive sessions and group study. This lecture is part of the Module Technology Management and can not separately choosen.
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	anagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Courses					
Title		Tun	Hrs/wk	СР	
Control Systems Theory and Design	u (L0656)	Typ Lecture	2	4	
Control Systems Theory and Design		Recitation Section (small)	2	2	
Module Responsible					
Admission Requirements					
	Introduction to Control Systems				
Knowledge					
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results			
Professional Competence	51	5 5			
Knowledge					
		ynamic systems are represented as state space n	nodels; they can	interpret the sys	
		l excitation as trajectories in state space			
		erties controllability and observability, and their re	ationship to stat	e feedback and s	
	estimation, respectively				
	They can explain the significance of				
		ate feedback and how it can be used to achieve tra	icking and distur	bance rejection	
	 They can extend all of the above to They can explain the a transform are 				
		nd its relationship with the Laplace Transform Is and transfer function models of discrete-time sys	toms		
		identification of ARX models of dynamic systems, a		fication problem	
	be solved by solving a normal equa		ind now the ident	incution problem	
	, , ,	model can be constructed from a discrete-time im	pulse response		
			puise response		
Skills	 Students can transform transfer fun 	nction models into state space models and vice ver			
		observability and construct minimal realisations	50		
	 They can design LQG controllers for 				
	 They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropria 				
	for a given sampling rate			approp.	
	They can identify transfer function models and state space models of dynamic systems from experimental data				
		using standard software tools (Matlab Control To			
	Simulink)				
Personal Competence	Chudanta ann marth in ann 11 ann an an an				
Social Competence	Students can work in small groups on spec	cinc problems to arrive at joint solutions.			
Autonomy	Students can obtain information from pro	ovided sources (lecture notes, software document	tation, experime	nt guides) and u	
	when solving given problems.				
	-				
	They can assess their knowledge in weeki	y on-line tests and thereby control their learning pr	ogress.		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56			
Credit points	6				
Course achievement	None				
Examination					
Examination duration and					
scale	120 11111				
	Electrical Engineering: Core Qualification:	Compulsory			
-	Energy Systems: Core Qualification: Electiv				
Tonowing curricula					
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory				
		pecialisation II. Engineering Science: Elective Com	oulsorv		
		g: Specialisation II. Electrical Engineering: Elective			
		g: Specialisation II. Mechatronics: Elective Compuls			
		: Specialisation Mechatronics: Elective Compulsory	- 1		
	Mechatronics: Core Qualification: Compuls				
		ificial Organs and Regenerative Medicine: Elective	Compulsory		
		plants and Endoprostheses: Elective Compulsory	- 2000 p		
		dical Technology and Control Theory: Compulsory			
	• • •	nagement and Business Administration: Elective Co	ompulsory		
		action: Core Qualification: Elective Compulsory			

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

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

Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0932)	202.01	Lecture	2	2
Production Planning and Control (L Production Planning and Control (L		Lecture Recitation Section (small)	2 1	2 1
Exercise: The Digital Enterprise (LO		Recitation Section (small)	1	1
	Prof. Hermann Lödding			_
Admission Requirements				
	Fundamentals of Production and Quality	Management		
Knowledge	· · · · · · · · · · · · · · · · · · ·			
	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the	e module in detail and take a critical position to them.		
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	International Management and Engineer	ring: Specialisation II. Product Development and Produ	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Sp	ecialisation Production and Logistics: Elective Compu	lsory	
	Biomedical Engineering: Specialisation A	Artificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation	Aanagement and Business Administration: Compulsor	У	
	Product Development, Materials and Pro	duction: Specialisation Product Development: Elective	e Compulsory	
	Product Development, Materials and Pro	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Pro	duction: Specialisation Materials: Elective Compulsor	y	
	Theoretical Mechanical Engineering: Spe	ecialisation Product Development and Production: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Teo	chnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	Course L0932: The Digital Enterprise		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Dr. Axel Friedewald		
Language	DE		
Cycle	WiSe		
Content	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered. Content: • Business Process Management and Data Modelling, Simulation • Knowledge and Competence Management • Process Management (PPC, Workflow Management) • Computer Aided Planning (CAP) and NC-Programming • Virtual Reality (VR) and Augmented Reality (AR) • Computer Aided Quality Management (CAQ) • Industry 4.0		
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002 Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006 Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004 Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007 Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006		

Course L0929: Production Pla	ourse L0929: Production Planning and Control		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management 		
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002 		

ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Hermann Lödding	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L0933: Exercise: The	Course L0933: Exercise: The Digital Enterprise	
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Axel Friedewald	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

-					
Courses					
Title			Тур	Hrs/wk	СР
Electronic Circuits for Medical Appl			Lecture Recitation Section (small)	2 1	3 2
Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl			Practical Course	1	1
Module Responsible				-	-
Admission Requirements					
	Fundamentals of electrical engineering				
Knowledge	randamentals of electrical engineering				
	After taking part successfully, students ha	ve reached the follow	ing learning results		
Professional Competence			ing learning results		
Knowledge					
Knowledge	 Students can explain the basic func 	tionality of the inform	ation transfer by the central i	nervous system	
	 Students are able to explain the but 	ild-up of an action pot	ential and its propagation alo	ng an axon	
	 Students can exemplify the commu- 	nication between neu	rons and electronic devices		
	 Students can describe the special feature 	eatures of low-noise a	mplifiers for medical applicat	ons	
	Students can explain the functions				
	 Students are able to discuss the po 	tential and limitations	of cochlea implants and artif	icial eyes	
Skills	Students can calculate the time defined the time defined to t	ependent voltage beh	avior of an action potential		
	 Students can give scenarios for furt 			l acquisition.	
	 Students can develop the block dia 				
	Students can define the building block				
Personal Competence					
Social Competence					
	Students are trained to solve prot	plems in the field of	medical electronics in teams	together with e	xperts with different
	professional background.	r conscific limitations of	a that they can ack for accist	anco to the right (in o
	Students are able to recognize theiStudents can document their work				
	whenever it is necessary				
	whenever he is necessary				
Autonomy					
,	 Students are able to realistically 	judge the status of	their knowledge and to de	fine actions for i	mprovements wh
	necessary.				
	Students can break down their worl				way.
	Students can handle the complex d Students are able to act in a response			5 11	
	 Students are able to act in a resport 	isible manner in all ca	ises and situations of experim	ental work.	
Workload in Hours	Independent Study Time 124, Study Time	in Locture EC			
Credit points		In Lecture 50			
Course achievement	Compulsory Bonus Form	Description			
	Yes None Subject theoreti	cal and			
	practical work				
	No None Excercises				
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Med				
Following Curricula	a Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Im				
	Biomedical Engineering: Specialisation Me				
	Biomedical Engineering: Specialisation Ma				
	Microelectronics and Microsystems: Specia			ompulsory	
	Theoretical Mechanical Engineering: Tech				
	Theoretical Mechanical Engineering: Spec	alisation Bio- and Med	dical Technology: Elective Cor	npulsory	

Course L0696: Electronic Cire	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	 Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Cire	urse L1056: Electronic Circuits for Medical Applications		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1408: Electronic Cir	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Module M1150: Conti	nuum Mechanics			
- -				
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533) Continuum Mechanics Exercise (L1	534)	Lecture Recitation Section (small)	2 2	3 3
Module Responsible		Rectation Section (Small)	L	5
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e	a in the module Mechanics II (forces and	d moments stre	ss linear strain fre
Knowledge	-	•	a momento, stre	ss, mear strain, ne
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concept	s to calculate the mechanical behavior of r	naterials.	
Skills	The students can set up balance laws and apply b	pasics of deformation theory to specific as	spects both in a	nnlied contexts as
Skiiis	research contexts.	disies of deformation theory to specific d	speces, both in a	pplied contexts as
Personal Competence				
Social Competence	The students are able to develop solutions, to pres	ent them to specialists in written form and	to develop ideas	s further.
Autonomy	The students are able to assess their own strength	s and weaknesses. They can independent	ly and on their o	wn identify and sol
	problems in the area of continuum mechanics and	acquire the knowledge required to this end	d.	
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective	Compulsory		
Following Curricula	Mechanical Engineering and Management: Speciali	sation Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: E	lective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	hnology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Managemer	nt and Business Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Co	ore Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualifica	tion: Elective Compulsory		

Course L1533: Continuum Mo	ourse L1533: Continuum Mechanics		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Christian Cyron		
Language	DE		
Cycle	WiSe		
Content	 kinematics of undeformed and deformed bodies balance equations (balance of mass, balance of energy,) stress states material modelling 		
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer		

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

Module M1151: Mate	rial Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum me	chanics as taught, e.g., in the modules Mechanic	s II and Continuu	ım Mechanics (for
Knowledge	and moments, stress, linear and nonlinear str	rain, free-body principle, linear and nonlinear cor	nstitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals o	f multidimensional consitutive material laws		
Skills	The students can implement their own mater	rial laws in finite element codes. In particular, th	e students can a	pply their knowle
	to various problems of material science and e	evaluate the corresponding material models.		
Personal Competence				
		present them to specialists and to develop idea	is further.	
Autonomy		rengths and weaknesses. They can independentl nd acquire the knowledge required to this end.	y and on their ou	wn identify and s
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: El	lective Compulsory		
-	Mechanical Engineering and Management: Sp			
-		ial Organs and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Impla	nts and Endoprostheses: Elective Compulsory		
		al Technology and Control Theory: Elective Com	oulsory	
			-	
	Biomedical Engineering: Specialisation Manac	gement and Business Administration: Elective Co		
	Biomedical Engineering: Specialisation Manage Product Development, Materials and Producti		mpulsory	
	Product Development, Materials and Producti		mpulsory	

Course L1535: Material Modeling		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials) - plasticity (permanent deformation due to one-time overload, e.g., in metal forming) - viscoelasticity (absorption of energy, e.g., in dampers) - creep (slow deformation under permanent load, e.g., in pipes)	
	This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.	
Literature		

Module Manual M.Sc. "Biomedical Engineering"

Course L1536: Material Mode	urse L1536: Material Modeling		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Christian Cyron		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M1199: Adva	nced Functional Materials			
C				
Courses				
Title Advanced Functional Materials (L1)	525)	Typ Seminar	Hrs/wk 2	CP 6
Module Responsible				-
Admission Requirements	None			
· · ·	Basic knowledge in Materials Science, e.	g. Materials Science I/II		
Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	The students will be able to explain the	properties of advanced materials along with the	heir applications in tech	nology, in particul
	metallic, ceramic, polymeric, semiconduc	ctor, modern composite materials (biomaterial	s) and nanomaterials.	
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design ne materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview of modern materials science, which enables them to select optimum materials combinations depending on the technic applications.			
Personal Competence				
Social Competence	The students are able to present solution	ns to specialists and to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and we 	eaknesses.		
	 gather new necessary expertise by 	y their own.		
Workload in Hours	Independent Study Time 152, Study Time	e in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Materials Science: Core Qualification: Co	mpulsory		
Following Curricula	Mechanical Engineering and Managemer	nt: Specialisation Materials: Elective Compulsor	У	
	• • •	rtificial Organs and Regenerative Medicine: Ele		
		nplants and Endoprostheses: Elective Compuls	-	
	5 5 1	ledical Technology and Control Theory: Elective		
		lanagement and Business Administration: Elect		
		hnical Complementary Course: Elective Compu cialisation Materials Science: Elective Compuls		
	mesication meenanical Engineering. Spe	clansation materials science. Elective compuls		

Course L1625: Advanced Functional Materials		
Тур	Seminar	
Hrs/wk	2	
СР	6	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Christian Cyron, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Stefan Fritz Müller	
Language	DE	
Cycle	WiSe	
Content	1. Porous Solids - Preparation, Characterization and Functionalities	
	2. Fluidics with nanoporous membranes	
	3. Thermoplastic elastomers	
	4. Optimization of polymer properties by nanoparticles	
	5. Fiber composites in automotive	
	6. Modeling of materials based on quantum mechanics	
	7. Biomaterials	
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.	

Module M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)

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Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16		Seminar	2	3
-	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
5	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr		Lecture	2	3
Experimental Methods for the Char		Lecture	2	3
Numerical Methods in Biomechanic	/	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821) Ceramics Technology (L0379)		Recitation Section (large) Lecture	2	2
5,		Lecture	Z	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
	Depends on choice of courses			
Credit points				
· · · · · ·	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
-	Biomedical Engineering: Specialisation Implants and E	-		
. enewing curricula	Biomedical Engineering: Specialisation Medical Techn		nulsory	
	5 5	5,	, ,	
	Biomedical Engineering: Specialisation Management a	and Business Administration: Elective Co	mpulsory	

Course L1663: Nature's Hiera	archical Materials
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a
	diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological
	materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic
	function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc. This lecture will focus on materials
	with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea),
	mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of
	the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334
	Journal publications

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics:
	 Fundamental properties and phenomena of electrical circuits Steady-state sinusoidal analysis of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves Useful microwave network parameters Transmission lines and basic results from transmission line theory Plane wave propagation, superposition, reflection and refraction General theory of waveguides Most important types of waveguides and their properties Radiation and basic antenna parameters Most important types of antennas and their properties Numerical techniques and CAD tools for waveguide and antenna design Fundamentals of Electromagnetic Compatibility Coupling mechanisms and countermeasures Shielding, grounding, filtering Standards and regulations EMC measurement techniques
Literature	 Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) D. M. Pozar, "Microwave Engineering", Wiley (2011) Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1588: Development	and Regulatory Approval of Implants
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 	
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009	

ourse L1890: Seminar Biomedical Engineering		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

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

Hrsvik 2 CP 4 Workcad in Hours Independent Study Time 92, Study Time in Lecture 28 Examination form Klausur Examination duration and scale	Тур	Lecture
Cp 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Examination Form Klassar Examination Form Klassar Examination of urstion and scale Ucture Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum-, heat and mass transfer • Examples for simplifications of the Navier-Stokes Equations • Unsteady momentum transfer • Examples for simplifications of the Navier-Stokes Engineering • Reelogy = Bioprocess Engineering • Coupling of momentum and heat transfer - Neactive mking, Chemical Process Engineering • Coupling of momentum- and mass transfer - Reactive mking, Chemical Process Engineering • Dumps and turbines - Energy and Environmental Process Engineering • Unstrast structures - heterogeneous catalysis • Pumps and turbines - Thergy and Environmental Process Engineering • Underduction into Computational Fluid Dynamics Literature 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen, Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.: Merkes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Jiviley & Sons, 1994.		
Workload in Hour Independent Study Time 92, Study Time in Lacture 28 Examination Form Klausur Examination duration and scale		
Examination Form Klausur Examination duration and scale Lecturer Prof. Michael Schlüter Language DE Cyclet WiSe Content Olfferential equations for momentum, heat and mass transfer Examples for simplifications of the Navier-Stokes Equations Unsteady momentum transfer Free shear layer, turbulence and free jets Free whear layer, turbulence and free jets Free whear layer, turbulence and free jets Row around particles - Solids Process Engineering Coupling of momentum and heat transfer - Thernal Process Engineering Robelogy - Bioprocess Engineering Coupling of momentum- and mass transfer - Reactive mixing, Chemical Process Engineering Wind- and Wave-Turbines - Netrogenoous catalysis Pumps and turbines - Energy - and Environmental Process Engineering Wind- and Wave-Turbines - Netrevable Energy Introduction into Computational Fluid Dynamics Introduction in Computational Fluid Dynamics Durst, F: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg 2006. Fox, R.W.; et al:: Introduction to Fluid Mechanics. J. Wiley & Sons. 1994. Herwig, H: Strömungsmechanik: Einführung in die Physik und die mathematische Modellierung von Strömunge Springer Verlag, Berlin, Heidelberg, New York. 2008. Kuhlmann, H.C: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner GWV Fachverlage GmbH, Wiesbaden, 2008. Kuhlmann, H.C: Strömungsmechanik: Kinfuhrung in die Physik von technischen		
Examination duration and scale Lecturer Prof. Michael Schlüter Language DE Cycle WiSe Content • Differential equations for momentum., heat and mass transfer • Examples for simplifications of the Navier-Stokes Equations • Unsteady momentum transfer • Free shear layer, turbulence and free jets • Gouping of momentum transfer • Free shear layer, turbulence and free jets • Coupling of momentum and heat transfer - Nermal Process Engineering • Coupling of momentum and heat transfer - Reactive mixing. Chemical Process Engineering • Coupling of momentum and mass transfer - Reactive mixing. Chemical Process Engineering • Coupling of momentum and mass transfer - Reactive mixing. Chemical Process Engineering • Coupling of momentum- and mass transfer - Reactive mixing. Chemical Process Engineering • Humps and turbines - Kenewable Energy • Introduction into Computational Fluid Dynamics Literature 1. Brouer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.: Grundlagen der Einphasen. und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.: Grundlagen der Einphasen. und Mehrphasenströmungen von Fluiden. Springer-Verlag, Berlin, Heidelberg 2006. 5. Fox, R.W. et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig. H.: Strömungsmechanik: Einführung in die Theorie der Strömungen: Vieweg+Teubner Verlag / GW Fachverlag, Berlin, Heideleberg, NeW Yok, 2009. 7. Herwig. H.: Strömungsmechanik		
scale Lecture Prof. Michael Schlüter Language DE Cycyte WiSe Content Differential equations for momentum-, heat and mass transfer Examples for simplifications of the Navier-Stokes Equations Unsteady momentum transfer Free shear layer, turbulence and free jets Flow around particles - Solids Process Engineering Coupling of momentum and heat transfer - Thermal Process Engineering Coupling of momentum and heat transfer - Thermal Process Engineering Flow threw porous structures - heterogeneous catalysis Pormps and turbines - Energy Introduction into Computational Fluid Dynamics Port Mew-Turbines - Energy Introduction into Computational Fluid Dynamics Crowe, C. T. Engineering fluid mechanics. Wiley, New York, 2009. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Viewey +Teubner Verlag / GW Fachverlage GmbH, Wiesbaden, 2009. Nethverlage GmbH, Wiesbaden, 2009. Herwig, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Strömungsmethoden, Strömungsmethoden, Springer-Verlag, Berlin, Heidelberg, New York, 2006. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Viewey +Teubner GW Fachverlage GmbH, Wiesbaden, 2009. Schule, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, L		Klausur
Lecture Prof. Michael Schlüter Language DE Content 		
Language DE Cyctel WiSe Content 		Des 6 Michael Cablüter
Cycle Wise Content 		
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 Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe Verlag, Berlin, Heidelberg, 2008. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. 		
12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.		11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simul	Course L1821: System Simulation		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Examination Form	Mündliche Prüfung		
Examination duration and	30 min		
scale			
Lecturer	Dr. Stefan Wischhusen		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0379: Ceramics Tech	nnology		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Rolf Janßen		
Language			
Cycle	WiSe		
Content	WiSe ntroduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powd pased processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of gla and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will addressed Examples will be discussed in order to give engineering students an understanding of technology development a aspecific applications of ceramic components. Content: 1. Introduction nhalt: 2. Raw materials 3. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques		
Literature	ASM Engineering Materials Hand	Ceramics", John Wiley & Sons, New York, 1975 dbook Vol.4 "Ceramics and Glasses", 1991 nic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

Courses				
		T	Une fools	CD
Title Introduction to Biochemistry and M	alecular Biology (10386)	Typ Lecture	Hrs/wk 2	CP 3
	Prof. Hans-Jürgen Kreienkamp	2000.0	-	5
Admission Requirements	None			
	None			
Knowledge	None			
	After taking part successfully, students h	ave reached the following learning results		
Professional Competence	Arter taking part successfully, statents in	ave reached the following learning results		
	The students can			
Kilowicuge				
	 describe basic biomolecules; 			
	 explain how genetic information is 	coded in the DNA;		
	explain the connection between D	NA and proteins;		
Skills	The students can			
		ular parameters for the course of a disease;		
	describe selected molecular-diagn			
	explain the relevance of these pro	cedures for some diseases		
Personal Competence				
Social Competence	The students can participate in discussion	ns in research and medicine on a technical le	vel.	
Αμτοποπγ	The students can develop understanding	of topics from the course, using technical lite	erature by themselves	
	···· · · · · · · · · · · · · · · · · ·			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German pr	ogram, 7 semester): Specialisation Biomedica	al Engineering: Compulsor	у
Following Curricula	General Engineering Science (German	program, 7 semester): Specialisation Mee	chanical Engineering, Fo	cus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Co	ompulsory		
	Electrical Engineering: Specialisation Med	lical Technology: Elective Compulsory		
	Engineering Science: Specialisation Biom	edical Engineering: Compulsory		
	General Engineering Science (English pro	gram, 7 semester): Specialisation Biomedical	l Engineering: Compulsory	1
	General Engineering Science (English	program, 7 semester): Specialisation Med	chanical Engineering, Fo	cus Biomechani
	Compulsory			
	Mechanical Engineering: Specialisation B	iomechanics: Compulsory		
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Elec	ctive Compulsory	
	Biomedical Engineering: Specialisation A	tificial Organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Elective	ve Compulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compul	sory	
	Technomathematics: Specialisation III. Er	gineering Science: Elective Compulsory		

Course L0386: Introduction t	to Biochemistry and Molecular Biology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008

~				
Courses				
Title		Тур	Hrs/wk	СР
Implants and Fracture Healing (L03		Lecture	2	3
Module Responsible				
Admission Requirements				
	It is recommended to participate in "Introduction into	Anatomie" before attending "Imp	lants and Fracture Heali	ng".
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how bo			
	The students can name different treatments for the	spine and hollow bones under give	n fracture morphologies	
Skills	The students can determine the forces acting within	the human body under quasi-stati	c situations under specif	fic assumptions.
	, s			
Personal Competence				
Social Competence	The students can, in groups, solve basic numerical n	nodeling tasks for the calculation o	f internal forces.	
Autonomv	The students can, in groups, solve basic numerical n	nodeling tasks for the calculation o	f internal forces.	
	5			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program,	7 semester): Specialisation Med	hanical Engineering, F	ocus Biomechan
Following Curricula	Compulsory			
	General Engineering Science (German program, 7 se	mester): Specialisation Biomedica	I Engineering: Compulso	ory
	Engineering Science: Specialisation Biomedical Engin	neering: Compulsory		
	General Engineering Science (English program, 7 ser	nester): Specialisation Biomedical	Engineering: Compulsor	У
	General Engineering Science (English program,	7 semester): Specialisation Mec	hanical Engineering, F	ocus Biomechan
	Compulsory			
	Mechanical Engineering: Specialisation Biomechanic	s: Compulsory		
	Biomedical Engineering: Specialisation Artificial Orga	ins and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Comput	sory	
	Biomedical Engineering: Specialisation Medical Tech		-	
	Biomedical Engineering: Specialisation Management			
	Orientierungsstudium: Core Qualification: Elective Co		are compaisory	
	Shenderungsstaarann eere Quunication. Elective Cl			
	Technomathematics: Specialisation III. Engineering S			

Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content	Topics to be covered include:	
	1. Introduction (history, definitions, background importance)	
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)	
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)	
	3.1 The spine in its entirety	
	3.2 Cervical spine	
	3.3 Thoracic spine	
	3.4 Lumbar spine	
	3.5 Injuries and diseases	
	4. Pelvis (anatomy, biomechanics, fracture treatment)	
	5 Fracture Healing	
	1 Basics and biology of fracture repair	
	5.2 Clinical principals and terminology of fracture treatment	
	5.3 Biomechanics of fracture treatment	
	5.3.1 Screws	
	5.3.2 Plates	
	5.3.3 Nails	
	5.3.4 External fixation devices	
	5.3.5 Spine implants	
	6.0 New Implants	
Literature	Cochran V.B.: Orthopädische Biomechanik	
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics	
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine	
	Nigg, B.: Biomechanics of the musculo-skeletal system	
	Schiebler T.H., Schmidt W.: Anatomie	
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat	

Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surg	ical techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students I	nave reached the following learning results		
Professional Competence				
Knowledge		of the human body and the materials being	used in medical engineer	ing, and their field
	use.			
Skills	The students can explain the advantage	s and disadvantages of different kinds of bio	materials.	
Personal Competence				1
Social Competence	the teachers.	related to materials being present or being u	ised for replacements wit	in student mates a
Autonomy	The students are able to acquire informa	ation on their own. They can also judge the in	formation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineer	ing: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano a	nd Hybrid Materials: Elective Compulsory		
		artificial Organs and Regenerative Medicine: I	Elective Compulsory	
	• • •	mplants and Endoprostheses: Compulsory		
		Aedical Technology and Control Theory: Elect		
		Anagement and Business Administration: Elective Com		
	5 5	hnical Complementary Course: Elective Com ecialisation Bio- and Medical Technology: Elec	, ,	

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	
CP	3
Workload in Hours Lecturer	Independent Study Time 62, Study Time in Lecture 28 Prof. Michael Morlock
Language	
Cycle	
Content	Topics to be covered include:
	1. Introduction (Importance, nomenclature, relations)
	2. Biological materials
	2.1 Basics (components, testing methods)
	2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.

Module M1342: Polyr	ners			
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polyme	ers (L0389)	Lecture	2	3
Processing and design with polyme	ers (L1892)	Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements				
	Basics: chemistry / physics / material scie	ence		
Knowledge				
Educational Objectives	After taking part successfully, students n	ave reached the following learning results		
Professional Competence	Students can use the knowledge of plast	ice and define the necessary testing and analy	sis	
Knowledge	Students can use the knowledge of plast	ics and define the necessary testing and analy	515.	
	They can explain the complex relationship	ips structure-property relationship and		
	the interactions of chemical structure of	the polymers, including to explain neighboring	contexts (e.g. sustaina	ability. environment
	protection).	· · · · · · · · · · · · · · · · · · ·		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
Skills	Students are capable of			
	- using standardized calculation metho	ods in a given context to mechanical prope	rties (modulus, streng	th) to calculate a
	evaluate the different materials.			
	- selecting appropriate solutions for med	hanical recycling problems and sizing example	stiffness corrosion re	sistance
	Screeting appropriate solutions for mee	indifical recycling problems and sizing example		sistance.
Personal Competence				
Social Competence	Students can			
	- arrive at funded work results in heterog	jenius groups and document them.		
	- provide appropriate feedback and handle feedback on their own performance constructively.			
Autonomy	Students are able to			
Autonomy				
	- assess their own strengths and weakne	sses.		
	- assess their own state of learning in spe	ecific terms and to define further work steps or	n this basis.	
	- assess possible consequences of their p	professional activity.		
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Materials Science: Specialisation Enginee	ering Materials: Elective Compulsory		
Following Curricula				
	5 5 1	rtificial Organs and Regenerative Medicine: Elect	1	
		lanagement and Business Administration: Elect ledical Technology and Control Theory: Elective		
		duction: Specialisation Production: Elective Cor		
		duction: Specialisation Materials: Elective Con		
		duction: Specialisation Product Development: E	-	
	Theoretical Mechanical Engineering: Tecl	hnical Complementary Course: Elective Compu	lsory	
	Theoretical Mechanical Engineering: Spe	cialisation Materials Science: Elective Compuls	ory	

Course L0389: Structure and	Departies of Delymout
	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Dr. Hans Wittich
Language	
Cycle	
	- Structure and properties of polymers
	 Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution Morphology amorph, crystalline, blends Properties
	Elasticity, plasticity, viscoelacity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Processing an	nd design with polymers
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich
Language	DE/EN
Cycle	WiSe
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining
	Designing with Polymers: Materials Selection; Structural Design; Dimensioning
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag
	Crawford: Plastics engineering, Pergamon Press
	Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag
	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Courses							
Title			Тур	Hrs/wk	СР		
Regenerative Medicine (L0347)	Mardiala - (12004	`	Seminar	2	3		
Lecture Tissue Engineering - Reger)	Seminar	2	3		
Module Responsible							
Admission Requirements	None						
Recommended Previous	None						
Knowledge							
Educational Objectives	After taking part succ	essfully, students have r	eached the following learning results				
Professional Competence	A.C	and the second second second					
Knowledge			udents will be able to describe the bas				
	the cultivation of anir		methods of tissue engineering. They are	e able to give a basic ov	erview of methods		
	The students can ou	utline the actual concep	ots of Tissue Engineering and regene	rative medicine and ca	an explain the ba		
	udnerlying principles	of the discussed topics.					
Skills	After successful com	letion of the module stu	dents are				
	 able to use me 	dical databases for acqu	irierung and presentation of relevant up	-to-date data independe	ntly		
		their work results in the					
			ods and the corresponding analysis inde				
	 able to analyse 	and evaluate current re	search topics for Tissue Engineering and	l regenerative medicine.			
Personal Competence							
Social Competence	Students are able to	work together as a team	with 2-4 students to solve given tasks a	and discuss their results	in the plenary and		
	defend them.						
	Students are able to I	effect their work orally a	nd discuss it with other students and tea	acners.			
Autonomy							
Autonomy							
	After completion of	this module, participan	ts will be able to solve a technical	problem in teams of	approx. 2-4 perso		
	independently includi	ng a presentation of the	results.				
Workload in Hours	Independent Study Ti	me 124, Study Time in L	ecture 56				
Credit points	6	me 124, Study fille III D					
Course achievement		Form	Description				
evalue achievement	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pi	rotocol for lecture series			
Examination	Presentation						
Examination duration and	Oral presentation + d	iscussion (30 min)					
scale							
Assignment for the	Biomedical Engineeri	ng: Specialisation Implan	ts and Endoprostheses: Elective Compul	sory			
Following Curricula	-		al Organs and Regenerative Medicine: Co				
-	Biomedical Engineeri	ng: Specialisation Manag	ement and Business Administration: Elec	ctive Compulsory			
	Diama dian Englishand	ng: Specialisation Medica					

Course L0347: Regenerative	Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
	The course deals with the application of biotechnological engineering principles for re-generation of human tissues. The main topics are "tissue engineering" for the generation of "artificial organs" such as cartilage, liver, blood vessel etc., and their applications: • Introduction (historical development, examples for medical and technical applications, commercial aspets) • Cell specific fundamentals (cell physiology, biochemistry, metabolism, special requirements for cell cultivation "in vitro") • Process specific fundamentals (requirements for culture systems, examples for reactor design, mathematical modelling, process and control strategies) • Examples for applications for clinical applications, drug testing and material testing The fundamentals will be presented by the lecturers. The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Course L1664: Lecture Tissue	e Engineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716
	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Courses						
Title				Тур	Hrs/wk	СР
Robotics and Navigation in Medicine (L0335)				Lecture	2	3
Robotics and Navigation in Medicin	e (L0338)			Project Seminar	2	2
Robotics and Navigation in Medicin	e (L0336)			Recitation Section (sma	all) 1	1
Module Responsible	Prof. Alexa	nder Schlae	efer			
Admission Requirements	None					
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of programming, e.g., in Java or C++ solid R or Matlab skills 					
Educational Objectives	After takin	a part succ	essfully students have	reached the following learning results		
Professional Competence		y pure succe	ession, statents have	reaction the following featuring results		
	detail. Syst systems re	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations. The students are able to design and evaluate navigation systems and robotic systems for medical applications.				
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independer	nt Study Tir	me 110, Study Time in	Lecture 70		
Credit points	6					
Course achievement	Compulsory Yes Yes	Bonus 10 % 10 %	Form Written elaboration Presentation	Description		
Examination	Written exa	am				
Examination duration and	90 minutes	5				
scale						
-				nce Engineering: Elective Compulsory		
				Technology: Elective Compulsory		
Following Curricula	Internation	ial Manager		Specialisation II. Electrical Engineering: Ele		
Following Curricula					Biotechnology: Electiv	e Compulsory
Following Curricula	Internation	-		Specialisation II. Process Engineering and		
Following Curricula	Internation Mechatroni	ics: Special	isation Intelligent Syste	ms and Robotics: Elective Compulsory		
Following Curricula	Internation Mechatroni Biomedical	ics: Special I Engineerin	isation Intelligent Syste	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele		
Following Curricula	Internation Mechatroni Biomedical Biomedical	iics: Speciali I Engineerin I Engineerin	isation Intelligent Systeng: Specialisation Artific ng: Specialisation Artific ng: Specialisation Impla	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls	sory	
Following Curricula	Internation Mechatroni Biomedical Biomedical Biomedical	iics: Speciali I Engineerin I Engineerin I Engineerin	isation Intelligent Syste ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls al Technology and Control Theory: Electiv	sory e Compulsory	
Following Curricula	Internation Mechatroni Biomedical Biomedical Biomedical Biomedical	iics: Speciali I Engineerin I Engineerin I Engineerin I Engineerin	isation Intelligent Syste ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic ng: Specialisation Mana	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls al Technology and Control Theory: Electiv gement and Business Administration: Elec	sory e Compulsory tive Compulsory	
Following Curricula	Internation Mechatroni Biomedical Biomedical Biomedical Product De	iics: Speciali I Engineerin I Engineerin I Engineerin I Engineerin evelopment	isation Intelligent Syste ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic ng: Specialisation Mana , Materials and Product	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls al Technology and Control Theory: Electiv gement and Business Administration: Elec ion: Specialisation Product Development: 1	sory e Compulsory tive Compulsory Elective Compulsory	
Following Curricula	Internation Mechatroni Biomedical Biomedical Biomedical Product De Product De	ics: Special I Engineerin I Engineerin I Engineerin I Engineerin evelopment,	isation Intelligent Syste ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic ng: Specialisation Mana , Materials and Product , Materials and Product	ims and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls al Technology and Control Theory: Electiv gement and Business Administration: Elec ion: Specialisation Product Development: I ion: Specialisation Production: Elective Com	sory e Compulsory tive Compulsory Elective Compulsory mpulsory	
Following Curricula	Internation Mechatroni Biomedical Biomedical Biomedical Product De Product De Product De	ics: Special I Engineerin I Engineerin I Engineerin I Engineerin evelopment, evelopment,	isation Intelligent Syste ng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic ng: Specialisation Mana , Materials and Product , Materials and Product , Materials and Product	ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Ele nts and Endoprostheses: Elective Compuls al Technology and Control Theory: Electiv gement and Business Administration: Elec ion: Specialisation Product Development: 1	sory e Compulsory tive Compulsory Elective Compulsory mpulsory pulsory	

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

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

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

Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in Le	cture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artificia	Organs and Regenerative Medicine: (Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compu	Ilsory	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elect	ive Compulsory	

Course L1963: Case Studies	ourse L1963: Case Studies for Regenerative Medicine and Tissue Engineering				
Тур	Seminar				
Hrs/wk	3				
СР	6				
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42				
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock				
Language	DE				
Cycle	SoSe				
Content					
Literature					

Module M0634: Introd	duction	into Me	edical Technol	ogy and Syste	ns		
Courses							
Title					Тур	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)					Lecture	2	3
Introduction into Medical Technology and Systems (L0343)					Project Seminar	2	2
Introduction into Medical Technolog	gy and Syste	v and Systems (L1876) Recitation Section (large) 1 1					1
Module Responsible	Prof. Alexa	Prof. Alexander Schlaefer					
Admission Requirements	None						
Recommended Previous				ulus)			
Knowledge							
	principles	of program	nming, R/Matlab				
Educational Objectives	After takin	g part suc	cessfully, students h	ave reached the follow	ing learning results		
Professional Competence							
Knowledge	The stude	nts can e	xplain principles of	medical technology, i	ncluding imaging systems,	computer aided s	surgery, and medica
	information	n systems.	. They are able to giv	ve an overview of regu	latory affairs and standards	in medical technol	ogy.
Chille	The studen						
SKIIIS	The studer	its are abl	e to evaluate system	is and medical devices	in the context of clinical ap	plications.	
Personal Competence							
Social Competence	The studer	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.					
Autonomy	The studer	nte can ref	flect their knowledge	and document the re	esults of their work. They ca	n present the res	ulte in an annronriat
Autonomy	manner.		nect their knowledge		esuits of their work. They ca	in present the rest	
	indinier.						
Workload in Hours	Independe	nt Study T	ime 110, Study Time	e in Lecture 70			
Credit points	6						
Course achievement	Compulsory		Form	Description			
	Yes	10 % 10 %	Written elaboratio Presentation	n			
Examination	Yes Written ex		Fresentation				
Examination duration and scale	90 minutes	5					
Assignment for the	General Fr	naineerina	Science (German pr	ogram 7 semester): S	pecialisation Biomedical Eng	ineering: Compuls	orv
Following Curricula					neering: Elective Compulsory		ory
i onothing curricula					ing Science: Elective Compu		
			Qualification: Elective		5	,	
	Electrical E	Engineerin	g: Core Qualification	Elective Compulsory			
	Engineerin	g Science:	Specialisation Biom	edical Engineering: Co	mpulsory		
	General Er	ngineering	Science (English pro	gram, 7 semester): Sp	ecialisation Biomedical Engi	neering: Compulso	ry
	-				ematics & Engineering Scien		ulsory
			5 5		er Science: Elective Compul	5	
			÷ •		ering Sciences: Elective Com	-	
		-	•		generative Medicine: Elective	Compulsory	
					heses: Elective Compulsory	mulcon	
		-	•		Control Theory: Elective Cor ess Administration: Elective (
				ngineering Science: Ele		Compuisory	
	· centionid	cinauco.	opecialisation III. El	ignicering Science. Lie	certe compaisory		

Course L0342: Introduction i	nto Medical Technology and Systems
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Course L0343: Introduction i	ourse L0343: Introduction into Medical Technology and Systems		
Тур	Project Seminar		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction i	nto Medical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonli					
Courses					
Title	Typ Hrs/wk CP				
Nonlinear Dynamics (L0702)	Integrated Lecture 4 6				
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous					
Knowledge					
	Linear Algebra				
	Engineering Mechanics				
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 Nonlinear Dynamics and to develop and research new terms				
	concepts.				
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and pro	ocedur			
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 then	nselves			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory				
Following Curricula	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 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 Management and Business Administration: Elective Compulsory				
	Product Development, Materials and Production: Core Qualification: Elective Compulsory				
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				
	Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory				

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

Module M0761: Semi				
Courses				
Title		Тур	Hrs/wk	СР
Semiconductor Technology (L0722 Semiconductor Technology (L0723		Lecture Practical Course	4	4 2
Module Responsible		Thethear course	L	2
Admission Requirements	None			
	Basics in physics, chemistry, material science and semicor	nductor devices		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	ollowing learning results		
Professional Competence				
Knowledge				
	Students are able			
	 to describe and to explain current fabrication techniques 	ies for Si and GaAs substrates	5,	
	 to discuss in details the relevant fabrication pr semiconductor devices and integrated circuits and 	ocesses, process flows and	the impact thereof or	the tabrication
	 to present integrated process flows. 			
Skills				
	Students are capable			
	• to analyze the impact of process parameters on the p	rocessing results,		
	 to select and to evaluate processes and 			
	to doublen process flows for the fabrication of comics	ductor dovices		
	to develop process flows for the fabrication of semicor	lauctor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab experi	ments in team work as well a	s to present and discus	s the results in fro
	of audience.			
Autonomy				
	Independent Study Time 96, Study Time in Lecture 84			
Credit points Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics and	Microsystems Technology, El	ective Compulsory	
-	Biomedical Engineering: Specialisation Nanoelectronics and			
	Biomedical Engineering: Specialisation Implants and Endo			
	Biomedical Engineering: Specialisation Medical Technolog	and Control Theory: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Management and B		ive Compulsory	
	Biomedical Engineering: Specialisation Management and B Microelectronics and Microsystems: Core Qualification: Ele		ive Compulsory	

CP 4 Workload in Hours In Lecturer Pr	
Workload in Hours In Lecturer Pr	
Lecturer Pr	
	ndependent Study Time 64, Study Time in Lecture 56
Language DI	rof. Hoc Khiem Trieu
	E/EN
Cycle So	oSe
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, highe order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic: temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuur evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximit and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique an electroplating, improving resolution excimer laser light source, immersion lithography, wet chemical etching: base hanced etching backsputtering, ion milling, chemical dry etching, RE, sidewall passivation) Process integration (CMOS proces, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact wire bonding, TAB and flip chip, wafer level package, 3D stacking)
	K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
S.	.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
U.	. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
H.	. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
К.	. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
S.	. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
P.	. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Course L0723: Semiconducto	ourse L0723: Semiconductor Technology	
Тур	Practical Course	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hoc Khiem Trieu	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0835: Huma	noid Robotics			
6				
Courses				
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk 2	CP 2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid robots. 			
	 Students can explain numariou robots. Students learn to apply basic control conce 	nts for different tasks in humanoid r	obotics	
	• Statents learn to apply basic control conce		0000003.	
Skills				
JAIIIS	Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature			
	Students generalize developed results and present them to the participants			
	 Students practice to prepare and give a pre- 	esentation		
Personal Competence				
Social Competence				
	 Students are capable of developing solution 	ns in interdisciplinary teams and pres	sent them	
	 They are able to provide appropriate feedb 	ack and handle constructive criticism	n of their own results	
Autonomy				
	 Students evaluate advantages and drawb 	backs of different forms of presenta	ation for specific tasks	and select the be
	solution			
	 Students familiarize themselves with a sci 	entific field, are able of introduce it	and follow presentation	ns of other studen
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lectur	e 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems a	nd Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Elect	tive Compulsory		
	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Elective Compul	sory	
	Biomedical Engineering: Specialisation Medical Te	chnology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Manageme	ent and Business Administration: Elec	ctive Compulsory	
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation	n Robotics and Computer Science: El	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Identi	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Classical control (frequency response, State space methods Discrete-time systems Linear algebra, singular value decomp Basic knowledge about stochastic pro 	position		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain the general fra nonlinear model structures They can explain how multilayer perco They can explain how an approximate They can explain the idea of subspace 	eptron networks are used to model nonli predictive control scheme can be based	near dynamics d on neural network mode	-
Skills	 Students are capable of applying the predicition error method to the experimental identification of linear and nonline models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
Personal Competence				
	Students can work in mixed groups on speci	fic problems to arrive at joint solutions.		
Autonomy	Students are able to find required informatic solve given problems.	on in sources provided (lecture notes, lite	erature, software docume	entation) and use it
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
-	Electrical Engineering: Specialisation Contro		ve Compulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Syste			
	Mechatronics: Specialisation System Design:			
	Biomedical Engineering: Specialisation Artific	• •		
	Biomedical Engineering: Specialisation Impla		•	
	Biomedical Engineering: Specialisation Medic	•••		
	Biomedical Engineering: Specialisation Mana Theoretical Mechanical Engineering: Technic	-		
	Theoretical Mechanical Engineering: Technic Theoretical Mechanical Engineering: Core Qu		pulsory	

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

Courses					
Courses		-		<u></u>	
Title Optimal and Robust Control (L0658		Typ Lecture	Hrs/wk 2	CP 3	
Optimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Classical control (frequency, response, rest locus)				
Knowledge	 Classical control (frequency response, root locus) State space methods 				
	 Linear algebra, singular value decomposition 				
-	After taking part successfully, students have reached the fol	lowing learning results			
Professional Competence					
Knowledge	• Students can explain the significance of the matrix Ri	ccati equation for the solution of	LQ problems.		
	• 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 contained.				
	 They can explain how model uncertainty can be repr They can explain how - based on the small gain theo 			•	
	an uncertain plant.	sent a tobase controller can ga	diance stability		
	They understand how analysis and synthesis condition	ns on feedback loops can be repr	esented as linear	matrix inequaliti	
Skills					
JKIIIS	• Students are capable of designing and tuning LQG con	ntrollers for multivariable plant m	odels.		
	• They are capable of representing a H2 or H-infinity de	esign problem in the form of a ge	neralized plant, a	nd of using stand	
	 software tools for solving it. They are capable of translating time and frequency domain specifications for control loops into constraints on closed-lo 				
	 They are capable of translating time and frequency domain specifications for control loops into constraints on closed-lo sensitivity functions, and of carrying out a mixed-sensitivity design. 				
	 They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-object 				
	robust controller.	induction an uncertain system	, and of designin	ig a mixed-objec	
	• They are capable of formulating analysis and synthes	sis conditions as linear matrix ine	equalities (LMI), a	nd of using stand	
	LMI-solvers for solving them.				
	• They can carry out all of the above using standard so	ftware tools (Matlab robust contro	ol toolbox).		
Personal Competence					
-	Students can work in small groups on specific problems to a	rrive at joint solutions.			
	Students are able to find required information in sources pro		software docume	ntation) and use	
	solve given problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement					
Examination					
Examination duration and scale	30 min				
Scale					
-	Electrical Engineering: Specialisation Control and Power Syst	tems Engineering: Elective Comp	ulsory		
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory	a Elective Computer			
	Aircraft Systems Engineering: Specialisation Aircraft System Mechatronics: Specialisation Intelligent Systems and Robotic				
	Mechatronics: Specialisation System Design: Elective Compu	1 5			
	Biomedical Engineering: Specialisation Artificial Organs and		Compulsory		
	Biomedical Engineering: Specialisation Implants and Endopr	-			
	Biomedical Engineering: Specialisation Medical Technology a	and Control Theory: Elective Com	pulsory		
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective Co	ompulsory		
	Product Development, Materials and Production: Specialisati				
	Product Development, Materials and Production: Specialisati				
			у		
	Product Development, Materials and Production: Specialisati	on Product Development: Electivo on Production: Elective Compulso on Materials: Elective Compulsor ary Course: Elective Compulsory	e Compulsory ory		

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

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

Courses				
Fitle	т) yn	Hrs/wk	СР
Marketing of Innovations (L2009)		`yp ecture	4	4
PBL Marketing of Innovations (L08		roject-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous				
Knowledge		. (sturteria alegaine desiri		
	 Basic understanding of business administration principle international business) 	es (strategic planning, decisio	on theory, p	oject managem
	Bachelor-level Marketing Knowledge (Marketing Instruments	. Market and Competitor Strate	egies, Basics	of Buying Behavi
	 Unerstanding the differences beweetn B2B and B2C marketi 		- J	
	Understanding of the importance of managing innovation in	global industrial markets		
	Good English proficiency; presentation skills			
Educational Objectives	After taking part successfully, students have reached the following	learning results		
Professional Competence	······································			
Knowledge	Students will have gained a deep understanding of			
	 Specific characteristics in the marketing of innovative porod 	ucts and services		
	 Approaches for analyzing the current market situation and t 			
	The gathering of information about future customer needs a			
	Concepts and approaches to integrate lead users and their r	needs into product and service	development	processes
	Approaches and tools for ensuring customer-orientation in the second secon	he development of new produc	ts and innova	tive services
	Marketing mix elements that take into consideration the sp	pecific requirements and chall	enges of inno	vative products
	services			
	 Pricing methods for new products and services The organization of complex sales forces and personal sellin 			
	Communication concepts and instruments for new products			
Chille				
Skills	Based on the acquired knowledge students will be able to:			
	 Design and to evaluate decisions regarding marketing and in Analyze markets by applying market and technology portfol 			
	 Conduct forecasts and develop compelling scenarios as a ba 			
	 Translate customer needs into concepts, prototypes and m 		ully apply ad	vanced methods
	customer-oriented product and service development		5 11 5	
	Use adequate methods to foster efficient diffusion of innova	tive products and services		
	Choose suitable pricing strategies and communication activity	ities for innovations		
	Make strategic sales decisions for products and services (i.e	. selection of sales channels)		
	 Apply methods of sales force management (i.e. customer value) 	lue analysis)		
Personal Competence				
Social Competence	The students will be able to			
	 have fruitful discussions and exchange arguments 			
	develop original results in a group			
	 present results in a clear and concise way 			
	carry out respectful team work			
Autonomy	The students will be able to			
	Acquire knowledge independently in the specific context and	d to map this knowledge on oth	ner new comp	lex problem field
	Consider proposed business actions in the field of marketing	and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement	None			
Examination	Subject theoretical and practical work			
	Written elaboration, excercises, presentation, oral participation			
scale	Global Technology and Innovation Management S. Entrensonsurshi	n: Caro Qualification: Computer	000	
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurshi International Management and Engineering: Specialisation I. Electi			
. Snowing curricula	Mechanical Engineering and Management: Specialisation Managem		.paisory	
	Biomedical Engineering: Specialisation Artificial Organs and Regen		pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthes			
	Biomedical Engineering: Specialisation Medical Technology and Co	ntrol Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management and Business	Administration: Compulsory		

Course L2009: Marketing of	Innovations
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
	Prof. Christian Lüthje
Language	
Cycle Content	I. Introduction
	 Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

Course L0862: PBL Marketing	g of Innovations
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1)
	forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation,
	managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will
	be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making wtihin a
	market simulation game.
Literature	

Courses				
Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame	ntal Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "fu	indamentals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have r	eached the following learning results		
Professional Competence				
	Students are able to describe the basic conce	nts of bioprocess engineering. They are able t	o classify different	t types of kinetics
Knowledge				
	, ,	o differentiate different types of inhibition.		
	•••	processes in bioreactors can be explained.		e capable to exp
	fundamental bioprocess management, steriliz	ation technology and downstream processing i	n detail.	
Skills	After successful completion of this module, stu	idents should be able to		
JAIIIS				
	 describe different kinetic approaches for 	or growth and substrate-uptake and to calculate	e the correspondir	ng parameters
	 predict qualitatively the influence of e 	energy generation, regeneration of redox equ	ivalents and grow	wth inhibition on
	fermentation process			
	 analyze bioprocesses on basis of stoich 	iometry and to set up / solve metabolic flux eq	uations	
		r different bioreactors and bioprocesses (anae		well as microaero
				well as microaero
	to compare them as well as to apply the			
	 propose solutions to complicated bloted 	chnological problems and to deduce the corres	ponding models	
	 to explore new knowledge resources an 	nd to apply the newly gained contents		
		te industrial use and to formulate solutions.		
		res as well as results in a scientific manner		
Personal Competence				
-	After completion of this module participants of	hauld ha able to debate technical quastions in	small teams to a	phanca the shilit
Social Competence	After completion of this module participants s			
	take position to their own opinions and increas	se their capacity for teamwork in engineering a	and scientific envi	ronments.
Autonomy	After completion of this module participants v	will be able to solve a technical problem in a t	eam independentl	v by organizing t
hatohomy	workflow and to present their results in a pler			y by organizing a
	worknow and to present their results in a pier			
Workload in Hours	Independent Study Time 96, Study Time in Le	cture 84		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes 5 % Subject theoretical	and		
	practical work			
Examination	Written exam			
Examination duration and				
scale	50 1111			
Scale				
Assignment for the	General Engineering Science (German program	n, 7 semester): Specialisation Process Enginee	ring: Compulsory	
Following Curricula	General Engineering Science (German program	m, 7 semester): Specialisation Bioprocess Engi	neering: Compulso	ory
	Bioprocess Engineering: Core Qualification: Co	ompulsory		
		n, 7 semester): Specialisation Bioprocess Engin	eering: Compulso	ry
		n, 7 semester): Specialisation Process Engineer	•	,
			• • •	
		al Organs and Regenerative Medicine: Compute	soi y	
	Biomedical Engineering: Specialisation Implan			
		al Technology and Control Theory: Elective Com		
	Biomedical Engineering: Specialisation Manag	ement and Business Administration: Elective C	ompulsory	
	Technomathematics: Specialisation III. Engine	ering Science: Elective Compulsory		

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	 Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) Kinetic of subtrate consumption and product formation (Prof. Zeng) Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) Transport process in a bioreactor (Prof. Zeng) Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	 K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess En	igineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

Course L0843: Bioprocess En	ngineering - Fundamental Practical Course
Тур	Practical Course
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Courses					
Title		Тур		Hrs/wk	СР
Applied Design Methodology in Me	chatronics (L1523)	Lecture		2	2
Applied Design Methodology in Me	chatronics (L1524)	Project-/pro	blem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical de	sign or computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students ha	we reached the following learning	results		
Professional Competence					
Knowledge	Science-based working on interdisciplinar	y product design considering targe	ted application of sp	ecific product	design technique
Skille	Creative bandling of processor used for s	ciontific proparation and formulati	on of comploy produc	st docian prob	lome (Applicatio
SKIIIS	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application various product design techniques following theoretical aspects.				
	various produce design reeninques ronown	ing theoretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with applicat			with application	
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the desi	gn and development process acco	rding to the target ar	nd topic of the	design
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-we	ork			
scale					
Assignment for the	International Management and Engineering	g: Specialisation II. Product Devel	opment and Production	on: Elective Co	ompulsory
Following Curricula	International Management and Engineering	g: Specialisation II. Mechatronics:	Elective Compulsory		
	Mechanical Engineering and Management	: Specialisation Product Developm	ent and Production: E	Elective Comp	ulsory
	Mechatronics: Specialisation System Desig	gn: Elective Compulsory			
	Biomedical Engineering: Specialisation Art			npulsory	
	Biomedical Engineering: Specialisation Im				
	Biomedical Engineering: Specialisation Me	•••		-	
	Biomedical Engineering: Specialisation Ma	-		-	
	Theoretical Mechanical Engineering: Spec			e Compulsory	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elec	tive Compulsory		

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	 Systematic analysis and planning of the design process for products combining a multitude of disciplines Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics) Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,) Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making Value-analysis Derivation of architectures and architectural management Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) Project-execution methods (Scrum, Kanbaan,) Presentation-skills Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) Evaluation of selected methods at practical examples in small teams
Literature	 Definition folgt Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoder und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff

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

Courses				
Title			Une fools	СР
Introduction to Anatomy (L0384)	Tyj	p :ture	Hrs/wk 2	3
Module Responsible			-	5
Admission Requirements				
Recommended Previous				
Knowledge	NOIC			
Educational Objectives	After taking part successfully, students have reached the following le	arning results		
Professional Competence				
•	The students can describe basal structures and functions of internal The students can describe the basic macroscopy and microscopy of	-	eletal system.	
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; th can explain the relevance of structures and their functions in the context of widespread diseases.			
Personal Competence				
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.			
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqu the relevant knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): Specia	lisation Biomedical Engine	ering: Compulsor	у
Following Curricula	Following Curricula General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus			cus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory			
	Electrical Engineering: Specialisation Medical Technology: Elective Co	ompulsory		
	Engineering Science: Specialisation Biomedical Engineering: Compute	sory		
	General Engineering Science (English program, 7 semester): S	pecialisation Mechanical	Engineering, Fo	cus Biomechani
	Compulsory			
	General Engineering Science (English program, 7 semester): Speciali	-	• • •	
	General Engineering Science (English program, 7 semester): Speciali	sation Biomedical Engineer	ring: Compulsory	1
	Mechanical Engineering: Specialisation Biomechanics: Compulsory			
	Biomedical Engineering: Specialisation Medical Technology and Cont		-	
	Biomedical Engineering: Specialisation Management and Business Ad			
	Biomedical Engineering: Specialisation Artificial Organs and Regener		mpulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses	. Elective Compulsory		

Course L0384: Introduction t	Course L0384: Introduction to Anatomy				
Тур	Lecture				
Hrs/wk					
CP					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Tobias Lange				
Language	DE				
Cycle	SoSe				
Content	General Anatomy				
	1 st week:	The Eucaryote Cell			
	2 nd week:	The Tissues			
	3 rd week:	Cell Cycle, Basics in Development			
	4 th week:	Musculoskeletal System			
	5 th week:	Cardiovascular System			
	6 th week:	Respiratory System			
	7 th week:	Genito-urinary System			
	8 th week:	Immune system			
	9 th week:	Digestive System I			
	10 th week:	Digestive System II			
	11 th week:	Endocrine System			
	12 th week:	Nervous System			
	13 th week:	Exam			
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016			

ourses					
itle		Тур	Hrs/wk	СР	
ntroduction to Radiology and Radi	ation Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
	After taking part successfully, students have	reached the following learning results			
Professional Competence Knowledge	Therapy				
	The students can distinguish different types of	of currently used equipment with respect	to its use in radiation th	erapy.	
	The students can explain treatment plans us	ed in radiation therapy in interdisciplinary	contexts (e.g. surgery,	internal medicine)	
	The students can describe the patients' passage from their initial admittance through to follow-up care.				
	Diagnostics				
	The students can illustrate the technical bas well as sectional imaging techniques (CT, MR		cluding angiography an	d mammography,	
	The students can explain the diagnostic as v techniques.	ell as therapeutic use of imaging technic	ques, as well as the tech	nnical basis for the	
	The students can choose the right treatment	method depending on the patient's clinic	al history and needs.		
	The student can explain the influence of tech	nical errors on the imaging techniques.			
	The student can draw the right conclusions b	ased on the images' diagnostic findings c	or the error protocol.		
Skills	Therapy				
JAIIIS	The students can distinguish curative and pa	liative situations and motivate why they	came to that conclusion.		
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.				
			logical aspects.		
	The students can use the therapeutic princip	e (effects vs adverse effects)			
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).				
	The student can assess what an individual groups, self-help groups, social services, psychological ser		e.g. follow-up treatment	, sports, social h	
	Diagnostics				
	The students can suggest solutions for repair	s of imaging instrumentation after having	g done error analyses.		
	The students can classify results of imaging anatomy, pathology and pathophysiology.	techniques according to different grou	ps of diseases based or	n their knowledge	
Personal Competence					
Social Competence	The students can assess the special social sit The students are aware of the special, off measures and can meet them appropriately.				
Autonomy	The students can apply their new knowledge The students can introduce younger students				
	The students are able to access anatomical and acquire the relevant knowledge themsel		e competently in conve	rsations on the to	
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28			
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 minutes				
scale Assignment for the	General Engineering Science (German progra	m 7 semester): Specialisation Biomedica	al Engineering: Compulse	151	
-	General Engineering Science (German progra				
ronowing curriculu	Compulsory				
	Data Science: Specialisation Medicine: Comp				
	Electrical Engineering: Specialisation Medical				
	Engineering Science: Specialisation Biomedic General Engineering Science (English pro Compulsory		chanical Engineering, F	ocus Biomechan	

General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introduction to Radiology and Radiation Therapy				
Тур	Lecture			
Hrs/wk	2			
СР				
	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring			
Cycle				
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments			
Literature	 "Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999 			
	• "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –			
	4. Auflage - Verlag Urban & Fischer – erschienen 02.03.2006			
	ISBN: 978-3-437-23960-1			
	"Strahlentherapie und Onkologie für MTA-R" von R. Sauer –			
	5. Auflage 2003 - Verlag Urban & Schwarzenberg – erschienen 08.12.2009			
	ISBN: 978-3-437-47501-6			
	"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus-			
	8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012			
	ISBN: 978-3-13-567708-8			
	• "Der Körper des Menschen " von A. Faller u. M. Schünke -			
	16. Auflage 2004 – Georg Thieme Verlag – erschienen 18.07.2012			
	ISBN: 978-3-13-329716-5			
	"Praxismanual Strahlentherapie" von Stöver / Feyer –			
	1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000			

Courses						
Title	Typ Hrs/wk CP					
Introduction to Physiology (L0385)	Lecture 2 3					
Module Responsible	Dr. Roger Zimmermann					
Admission Requirements	None					
Recommended Previous	None					
Knowledge						
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge	The students can					
	 describe the basics of the energy metabolism; 					
	describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.					
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, developr					
	of forces and vital functions) and relate them to similar technical systems.					
Personal Competence						
Social Competence	The students can conduct discussions in research and medicine on a technical level.					
	The students can find solutions to problems in the field of physiology, both analytical and metrological.					
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature					
Autonomy	themselves.					
	Independent Study Time 62, Study Time in Lecture 28					
Credit points						
Course achievement						
	Written exam					
Examination duration and	60 minutes					
scale	Constal Engineering Science (Cormon program, 7 comestar), Enginisation Biomedical Engineering, Computerry					
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha					
Tonowing curricula	Compulsory					
	Data Science: Specialisation Medicine: Compulsory					
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory					
	Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory					
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha					
	Compulsory					
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory					
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory					
	Mechanical Engineering: Specialisation Biomechanics: Compulsory					
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory					
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory					
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory					

Course L0385: Introduction t	o Physiology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Gerhard Engler
Language	DE
Cycle	SoSe
Content	
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier

Courses						
Title		Тур	Hrs/wk	СР		
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3		
Module Responsible	Prof. Michael Morlock					
Admission Requirements	None					
Recommended Previous	It is recommended to participate in "Implanta	ate und Frakturheilung" before attending	"Experimentelle Methode	n".		
Knowledge						
Educational Objectives	After taking part successfully, students have	reached the following learning results				
Professional Competence						
Knowledge	The students can describe the different ways	how bones heal, and the requirements f	or their existence.			
	The students can name different treatments	for the spine and hollow bones under giv	en fracture morphologies			
	The students can describe different measure	ment techniques for forces and moveme	nts, and choose the adeq	uate technique for		
	given task.	·				
Skills	The students can describe the basic handling	of several experimental techniques use	d in biomechanics.			
Personal Competence						
Social Competence	The students can, in groups, solve basic expe	erimental tasks.				
Autonomy	The students can, in groups, solve basic expe	erimental tasks.				
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28				
Credit points	3					
Course achievement	None					
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	General Engineering Science (German pro	gram, 7 semester): Specialisation Me	echanical Engineering, F	ocus Biomechanic		
Following Curricula	Compulsory					
	General Engineering Science (German progra		al Engineering: Compulso	ry		
	Engineering Science: Specialisation Biomedic					
	General Engineering Science (English pro	gram, 7 semester): Specialisation Me	chanical Engineering, F	ocus Biomechanic		
	Compulsory					
	General Engineering Science (English progra	· ·	• • •	•		
	General Engineering Science (English progra		al Engineering: Elective Co	mpulsory		
	Mechanical Engineering: Specialisation Biomo		lective Compulsory			
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla					
	Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic					
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory					

Course L0377: Experimental	rse L0377: Experimental Methods in Biomechanics			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	ndent Study Time 62, Study Time in Lecture 28			
Lecturer	ichael Morlock			
Language	DE			
Cycle	SoSe			
Content				
Literature	ird in der Veranstaltung bekannt gegeben			

Courses						
Title		Түр	Hrs/wk	СР		
Artificial Joint Replacement (L1306)		Lecture	2	3		
Module Responsible	Prof. Michael Morlock					
Admission Requirements	None					
Recommended Previous	Basic knowledge of orthopedic and sur	gical techniques is recommended.				
Knowledge						
Educational Objectives	After taking part successfully, students	have reached the following learning results				
Professional Competence						
Knowledge	The students can name the different k	inds of artificial limbs.				
CL III.	-					
SKIIIS	The students can explain the advantage	ges and disadvantages of different kinds of end	ioprotneses.			
Personal Competence						
Social Competence	The students are able to discuss issue	s related to endoprothese with student mates a	and the teachers.			
Autonomic	The students are able to acquire information on their own. They can also judge the information with respect to its credibi					
Autonomy	The students are able to acquire more	nation on their own. They can also judge the in	normation with respect to	its creaibility.		
Workload in Hours	Independent Study Time 62, Study Tin	ne in Lecture 28				
Credit points	3					
Course achievement	None					
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	International Management and Engine	ering: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory		
Following Curricula	Materials Science: Specialisation Nano	and Hybrid Materials: Elective Compulsory				
		Artificial Organs and Regenerative Medicine: I	Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory					
	• • •	Medical Technology and Control Theory: Elect				
		Management and Business Administration: Ele	ective Compulsory			
	Orientierungsstudium: Core Qualificati					
		echnical Complementary Course: Elective Com pecialisation Bio- and Medical Technology: Elec				

Course L1306: Artificial Joint	Replacement				
Тур	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Michael Morlock				
Language	DE				
Cycle	SoSe				
Content	Inhalt (deutsch)				
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)				
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)				
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)				
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)				
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)				
	E SCHULTER (Anatomie, Biomechanik, Gelenkersatz)				
	ER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)				
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)				
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)				
Literature	Literatur:				
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.				
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994				
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.				
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.				
	Sobotta und Netter für Anatomie der Gelenke				

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Courses							
Title Feedback Control in Medical Techn		Typ Lecture	Hrs/wk	CP 3			
Module Responsible		Lecture	2	5			
Admission Requirements							
	Basics in Control, Basics in Physiology						
Knowledge	busies in control, busies in mysiology						
	After taking part successfully, students h	nave reached the following learning results					
Professional Competence							
Knowledge	The lecture will introduce into the fasc	inating area of medical technology with the	engineering point of vi	ew. Fundamentals			
-	human physiology will be similarly introd	duced like knowledge in control theory.					
	Internal control loops of the human be	dy will be discussed in the same way like t	he design of external c	lacad loop system			
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system						
	example in for anesthesia control.						
	The handling of PID controllers and m	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will b					
	illustrated. The operation of simple equivalent circuits will be discussed.						
Skills	Application of modeling, identification, control technology in the field of medical technology.						
Personal Competence							
	Students can develop solutions to specif	ic problems in small groups and present their	results				
Autonomy	y Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate the intervention of the interve						
	their knowledge and to take control of their learning process. They can combine knowledge from different courses to form consistent whole.						
	consistent whole.						
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28					
Credit points	3						
Course achievement	None						
Examination	Oral exam						
Examination duration and	20 min						
scale							
Assignment for the	Electrical Engineering: Specialisation Me	dical Technology: Elective Compulsory					
Following Curricula	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory				
		mplants and Endoprostheses: Elective Compu	•				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory						
		Ianagement and Business Administration: Ele					
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Comp	ulsory				

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

Courses								
itle	<u> </u>	Тур	Hrs/wk	СР				
dvanced Topics in Control (L0661)		Lecture	2	3				
dvanced Topics in Control (L0662)		Recitation Section (small)	2	3				
Module Responsible		·····		-				
-								
	None							
	H-infinity optimal control, mixed-sensitivity design, linear m	natrix inequalities						
Knowledge								
Educational Objectives	After taking part successfully, students have reached the fo	bllowing learning results						
Professional Competence								
Knowledge	 Students can explain the advantages and shortcomir They can explain the representation of nonlinear sys They can explain how stability and performance come They can explain how gridding techniques can be use They are familiar with polytopic and LFT represent associated with each of these model structures Students can explain how graph theoretic concept systems They can explain the convergence properties of first They can explain analysis and synthesis conditions for an actuator/sensor array They can explain (in outline) the extension of the 	tems in the form of quasi-LPV systems in the form of quasi-LPV systems can be form ed to solve analysis and synthesis itations of LPV systems and som ts are used to represent the con- corder consensus protocols or formation control loops involving of spatially invariant distributed s	ems nulated as LMI cc problems for LPV e of the basic s mmunication top g either LTI or LPV ystems that are o	systems synthesis techniqu ology of multiage / agent models discretized accordi				
Skills	 Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity design of scheduled 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 Matlab tools provided Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox 							
Personal Competence								
Personal Competence	Students can work in small groups and arrive at laist service	5						
	Students can work in small groups and arrive at joint result.		offware de la	atation) and the "				
-	Students are able to find required information in sources provide solve given problems.	iovided (lecture notes, literature, s						
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56							
Credit points	6							
Course achievement								
Examination								
Examination duration and	1)))) 0							
scale								
Accient and for the	Electrical Engineering: Specialisation Control and Power Sys		ulsory					
Assignment for the	Aircraft Systems Engineering: Specialisation Avionic System	ns: Elective Compulsory						
-	Aircraft Systems Engineering: Specialisation Aircraft System							
Following Curricula		ompulsory						
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective C	Simparsony	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory					
Following Curricula			ory					
Following Curricula		II. Mechatronics: Elective Compuls	ory					
Following Curricula	International Management and Engineering: Specialisation	II. Mechatronics: Elective Compulso pulsory	ory					
Following Curricula	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Comp	II. Mechatronics: Elective Compulso pulsory ics: Elective Compulsory	ory					
Following Curricula	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Comp Mechatronics: Specialisation Intelligent Systems and Roboti	II. Mechatronics: Elective Compuls pulsory ics: Elective Compulsory rostheses: Elective Compulsory						
Following Curricula	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Comp Mechatronics: Specialisation Intelligent Systems and Roboti Biomedical Engineering: Specialisation Implants and Endop Biomedical Engineering: Specialisation Medical Technology	II. Mechatronics: Elective Compulso pulsory ics: Elective Compulsory rostheses: Elective Compulsory and Control Theory: Elective Comp	pulsory					
Following Curricula	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Comp Mechatronics: Specialisation Intelligent Systems and Roboti Biomedical Engineering: Specialisation Implants and Endop	II. Mechatronics: Elective Compulsion pulsory ics: Elective Compulsory rostheses: Elective Compulsory and Control Theory: Elective Compusion usiness Administration: Elective Compusion	pulsory					

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

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

Courses						
Title			1	Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and	Applications (L0371)			ecture	3	5
Bioelectromagnetics: Principles and	Applications (L0373)		F	ecitation Section (small)	2	1
Module Responsible	Prof. Christian Schust	er				
Admission Requirements	None					
Recommended Previous Knowledge	Basic principles of phy	ysics				
Educational Objectives	After taking part succ	essfully, students have r	reached the following	learning results		
Professional Competence						
Knowledge	of electromagnetic fie them corresponding techniques for charac	elds in biological tissue. to wavelength and freq	They can define an quency of the fields. gnetic fields in pract	ods of bioelectromagnetics, d exemplify the most impo They can give an overvie cical applications . They ca gy.	ortant physical ph w over measure	nenomena and ord ment and numeric
Skills	do this they can rela important effects tha frequency, respective	te to and make use of at these models predict aly, and they can analyze	the elementary solut for biological tissue e them in a quantitat	behavior of electromagnetic tions of Maxwell's Equation , they can order the effec tive way. They are able to o tic fields for therapeutic and	ns. They are able ts corresponding develop validation	to assess the mo to wavelength and strategies for the
Personal Competence Social Competence	Students are able to English (e.g. during sr	• •	ct related tasks in sr	nall groups. They are able	to present their	results effectively
Autonomy	context of the lecture other lectures (e.g. t	e. They are able to make	e a connection betwe ic fields, fundament	d, professional publication een their knowledge obtair als of electrical engineerin	ed in this lecture	with the content
Workload in Hours	Independent Study Ti	me 110, Study Time in L	ecture 70			
	6	-				
Course achievement	Compulsory Bonus Yes None	Form Presentation	Description			
Examination	Oral exam	i resentation				
Examination Examination duration and	45 min					
Examination duration and scale	45					
5	Electrical Engineering International Manager Biomedical Engineerin Biomedical Engineerin	: Specialisation Medical ment and Engineering: S ng: Specialisation Artifici ng: Specialisation Manag	Technology: Elective Specialisation II. Elect al Organs and Regen gement and Business	rical Engineering: Elective (erative Medicine: Elective (Administration: Elective Co	Compulsory Compulsory ompulsory	ve Compulsory
	Biomedical Engineering	ng: Specialisation Medica	al Technology and Co	ntrol Theory: Elective Com	ouisorv	
		ng: Specialisation Medica ng: Specialisation Implan		ntrol Theory: Elective Comp es: Elective Compulsory	pulsory	

Тур	Lecture
Hrs/wk	
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	
Cycle	
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Course L0373: Bioelectromag	urse L0373: Bioelectromagnetics: Principles and Applications	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	1	
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Specialization Medical Technology and Control Theory

Module M0623: Intell	gent Systems in Me	dicine			
Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0	331)		Lecture	2	3
Intelligent Systems in Medicine (L0	334)		Project Seminar	2	2
Intelligent Systems in Medicine (LO	333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous	 principles of math (alg 	obra analysis/calculus)			
Knowledge	 principles of math (aig principles of stochastic 				
		ning, Java/C++ and R/Matl	ab		
	advanced programmin				
Educational Objectives	After taking part successfully	, students have reached th	e following learning results		
Professional Competence					
Knowledge	The students are able to ana	lyze and solve clinical tre	atment planning and decision suppo	ort problems using	methods for search
			thods for classification and their res		-
			t methods for representing medical		
		and explain challenges of	lue to the clinical nature of the data	a and its acquisitio	on and due to privac
	and safety requirements.				
Skills	The students can give reason	ns for selecting and adapt	ing methods for classification, regre	ession, and predict	ion. They can asses
	the methods based on actual	patient data and evaluate	the implemented methods.		
Personal Competence					
Social Competence	The students discuss the resu	Ilts of other groups, provid	e helpful feedback and can incoorpo	orate feedback into	their work.
Autonomy	The students can reflect thei manner.	r knowledge and documer	nt the results of their work. They ca	n present the resu	ults in an appropriat
Workload in Hours	Independent Study Time 110	, Study Time in Lecture 70			
Credit points	6				
Course achievement	Compulsory Bonus Form		ription		
		n elaboration			
		ntation			
	Written exam				
	90 minutes				
scale					
Assignment for the	Computer Science: Specialisa	tion II: Intelligence Engine	ering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specia				
	Mechatronics: Specialisation				
			and Regenerative Medicine: Elective	e Compulsory	
			doprostheses: Elective Compulsory		
			ogy and Control Theory: Elective Con		
		-	d Business Administration: Elective		
	-	•	nentary Course: Elective Compulsory		
	meoretical Mechanical Engin	eening: specialisation BIO-	and Medical Technology: Elective Co	Simpulsory	

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

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

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

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	63)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
-				
	Biomedical Engineering: Specialisation Management a	and Business Administration: Elective Co	mpulsory	

Course L1663: Nature's Hiera	archical Materials
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc.This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications

Course L1669: Introduction t	o Waveguides, Antennas, and Electromagnetic Compatibility
	Lecture
Hrs/wk	
CP	
	Thependent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and	30 min
scale	Prof. Christian Schuster
Language	
Cycle	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.
	Topics:
	- Fundamental properties and phenomena of electrical circuits
	- Steady-state sinusoidal analysis of electrical circuits
	 Fundamental properties and phenomena of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves
	- Useful microwave network parameters
	- Transmission lines and basic results from transmission line theory
	- Plane wave propagation, superposition, reflection and refraction
	- General theory of waveguides
	- Most important types of waveguides and their properties
	- Radiation and basic antenna parameters
	- Most important types of antennas and their properties
	- Numerical techniques and CAD tools for waveguide and antenna design
	- Fundamentals of Electromagnetic Compatibility
	- Coupling mechanisms and countermeasures
	- Shielding, grounding, filtering
	- Standards and regulations
	- EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Тур	Recitation Section (small)
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development	Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Roman Nassutt		
Language	DE		
Cycle	WiSe		
Content			
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html 		

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Me	thods in Biomechanics			
Тур	Seminar			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Klausur			
Examination duration and	90 Minuten			
scale				
Lecturer	Prof. Michael Morlock			
Language	DE/EN			
Cycle	SoSe			
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 			
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009			

Course L1890: Seminar Biomedical Engineering				
Тур	Seminar			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	eferat			
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)			
scale				
Lecturer	Prof. Michael Morlock			
Language	DE			
Cycle	WiSe			
Content				
Literature	Keine			

Course L1130: Six Sigma				
Тур	Lecture			
Hrs/wk				
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Klausur			
Examination duration and	90 Minuten			
scale				
Lecturer	Prof. Claus Emmelmann			
Language				
Cycle	WiSe			
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 			
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008			

ourse L0001: Fluid Mechani	Lecture					
Тур						
Hrs/wk						
СР						
Workload in Hours	ndependent Study Time 92, Study Time in Lecture 28					
Examination Form	Klausur					
Examination duration and						
scale						
Lecturer						
Language						
Cycle	WiSe					
Content	Differential equations for momentum-, heat and mass transfer					
	Examples for simplifications of the Navier-Stokes Equations					
	Unsteady momentum transfer					
	Free shear layer, turbulence and free jets					
	 Flow around particles - Solids Process Engineering 					
	Coupling of momentum and heat transfer - Thermal Process Engineering					
	Rheology – Bioprocess Engineering					
	 Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering 					
	 Flow threw porous structures - heterogeneous catalysis 					
	 Pumps and turbines - Energy- and Environmental Process Engineering 					
	Wind- and Wave-Turbines - Renewable Energy					
	Introduction into Computational Fluid Dynamics					
Literature	1. Derver H., Cruzdiana der Sinsland, und Mahrshanderfrämmenn Mader Geuseländer Annu. Frankfurt (M) 1071					
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.					
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.					
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.					
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg					
	2006.					
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.					
	 Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunger Springer Verlag, Berlin, Heidelberg, New York, 2006. 					
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW Fachverlage GmbH, Wiesbaden, 2008. 					
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007					
	 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner GWV Fachverlage GmbH, Wiesbaden, 2009. 					
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.					
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe					
	Verlag, Berlin, Heidelberg, 2008.					
	12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.					
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.					

Course L1820: System Simul	ation				
Тур	Lecture				
Hrs/wk					
CP	2				
Workload in Hours	ndependent Study Time 32, Study Time in Lecture 28				
Examination Form	Mündliche Prüfung				
Examination duration and	30 min				
scale					
Lecturer	Dr. Stefan Wischhusen				
Language	DE				
Cycle	WiSe				
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems				
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011. 				

Course L1821: System Simul	Course L1821: System Simulation			
Тур	ecitation Section (large)			
Hrs/wk	1			
СР	2			
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14			
Examination Form	idliche Prüfung			
Examination duration and	0 min			
scale				
Lecturer	Dr. Stefan Wischhusen			
Language	DE			
Cycle	WiSe			
Content	See interlocking course			
Literature	ee interlocking course			

Module Manual M.Sc. "Biomedical Engineering"

Course L0379: Ceramics Tech	nnology				
Тур	Lecture				
Hrs/wk	2				
CP					
Workload in Hours	Independent Study Time 62, Stu	udy Time in Lecture 28			
Examination Form	Klausur				
Examination duration and	90 Minuten				
scale					
Lecturer	Dr. Rolf Janßen				
Language					
Cycle	WiSe				
Content	Wise Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder based processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components. Content: 1. Introduction Inhalt: 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques				
Literature	W.D. Kingery, "Introduction to Ceramics", John Wiley & Sons, New York, 1975 ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991 D.W. Richerson, "Modern Ceramic Engineering", Marcel Decker, New York, 1992				
	Skript zur Vorlesung				

Courses							
Title		Тур	Hrs/wk	СР			
ntelligent Autonomous Agents and	Cognitive Robotics (L0341)	Lecture	2	4			
ntelligent Autonomous Agents and	Cognitive Robotics (L0512)	Recitation Section (small) 2	2			
Module Responsible	Rainer Marrone						
Admission Requirements	None						
Recommended Previous	Vectors, matrices, Calculus						
Knowledge							
Educational Objectives	After taking part successfully, students have	ve reached the following learning results					
Professional Competence							
	(goals, utilities, environments). They can d can be discussed in terms of decision pro world scenarios, students can summarize formalism in static and dynamic settings. settings, with and with complete access t solving (partially observable) Markov deci Students can identify techniques for simu desired states. Students can explain coord of equilibria, social choice functions, voting Students can select an appropriate agent students can derive decision trees and ap networks/dynamic Bayesian networks an different sampling techniques for simplifie best action or policies for concrete setting	n, define intelligence in terms of rational beh lescribe the main features of environments. T iblems and algorithms for solving these prob how Bayesian networks can be employed as In addition, students can define decision ma to the state of the environment. In this cont sion problems, and they can recall technique iltaneous localization and mapping, and can ination problems and decision making in a m g protocol, and mechanism design techniques. architecture for concrete agent application ply basic optimization techniques. For those a d apply bayesian reasoning for simple que to agent scenarios. For simple and complex of s. In multi-agent situations students will apply t decision making students will apply different	he notion of adversa lems. For dealing with a knowledge represe aking procedures in s ext, students can de es for measuring the explain planning tec ulti-agent setting in t scenarios. For simpli applications they car ries. Students can a lecision making stud y techniques for find	rial agent cooperat th uncertainty in re- intation and reason simple and sequen escribe techniques e value of informat chniques for achiev erm of different typ fied agent applicat n also create Bayes also name and ap ents can compute ing different equili			
Personal Competence Social Competence	Students are able to discuss their solutions	s to problems with others. They communicate	in English				
Autonomy	Students are able of checking their Unders	tanding of complex concepts by solving varair	its of concrete proble	:1115			
Workload in Hours	Independent Study Time 124, Study Time i	in Lecture 56					
Credit points	6						
Course achievement	None						
Examination	Written exam						
Examination duration and	90 minutes						
scale							
-	Computer Science: Specialisation II: Intellig						
Following Curricula							
	Mechatronics: Technical Complementary C						
	Mechatronics: Specialisation Intelligent Sys		tivo Compulsor				
	• • •	ficial Organs and Regenerative Medicine: Elec					
		plants and Endoprostheses: Elective Compulso	•				
		dical Technology and Control Theory: Elective nagement and Business Administration: Electi					
	biomedical Engineering: Specialisation Mar	agement and pusitiess Authinistration: Electr	ve compuisory				
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compute	sorv				
	5	ical Complementary Course: Elective Compuls alisation Robotics and Computer Science: Elec	5				

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

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

Module M0746: Micro	system Engine	ering				
Courses						
Title				Тур	Hrs/wk	СР
Microsystem Engineering (L0680)				Lecture	2	4
Microsystem Engineering (L0682)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper					
Admission Requirements	None					
Recommended Previous	Basic courses in phys	ics, mathematics	and electric engineering			
Knowledge						
Educational Objectives	After taking part succ	essfully, students	s have reached the follow	ing learning results		
Professional Competence						
Knowledge	The students know a	bout the most in	nportant technologies ar	nd materials of MEMS as well as	their applica	tions in sensors and
	actuators.					
SKIIIS		analyze and de	escribe the functional be	ehaviour of MEMS components	and to evalu	ate the potential of
	microsystems.					
Personal Competence						
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.					
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with					
	other fields.					
Workload in Hours	Independent Study Ti	me 124, Study Ti	me in Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	No 10 %	Presentation				
Examination	Written exam					
Examination duration and	2h					
scale						
Assignment for the	Electrical Engineering	: Core Qualification	on: Compulsory			
Following Curricula	International Manage	ment and Engine	ering: Specialisation II. Ele	ectrical Engineering: Elective Cor	npulsory	
	International Manage	ment and Engine	ering: Specialisation II. Me	echatronics: Elective Compulsory		
	•			tronics: Elective Compulsory		
		Mechatronics: Specialisation System Design: Elective Compulsory				
	-	•		enerative Medicine: Elective Con	npulsory	
	-	•		eses: Elective Compulsory		
	-	•		Control Theory: Elective Compute		
	-	•	-	ess Administration: Elective Comp	oulsory	
		-	ore Qualification: Elective			
		• •		Course: Elective Compulsory	loon	
	i neoretical Mechanic	ai Engineering: Sp	pecialisation Bio- and Med	lical Technology: Elective Compu	lisory	

Course L0680: Microsystem	Engineering			
Тур	Lecture			
Hrs/wk	2			
СР	4			
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28			
Lecturer	Dr. rer. nat. Thomas Kusserow			
Language	EN			
Cycle	WiSe			
Content	Object and goal of MEMS			
	Scaling Rules			
	Lithography			
	Film deposition			
	Structuring and etching			
	nergy conversion and force generation			
	ectromagnetic Actuators			
	eluctance motors			
	iezoelectric 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	Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Dr. rer. nat. Thomas Kusserow		
Language	EN		
Cycle	WiSe		
Content	Examples of MEMS components		
	Layout consideration		
	Electric, thermal and mechanical behaviour		
	Design aspects		
Literature	Wird in der Veranstaltung bekannt gegeben		

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the	ollowing learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibrat	on Theory and develop them fur	ther.	
Skills	Students are able to denote methods of Vibration Theory	and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks	in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory			
Following Curricula	International Management and Engineering: Specialisation	II. Mechatronics: Elective Comp	oulsory	
	Mechanical Engineering and Management: Specialisation	lechatronics: Elective Compulso	ory	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs ar	d Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Medical Technolog	and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Management and		e Compulsory	
	Product Development, Materials and Production: Core Qua			
	Naval Architecture and Ocean Engineering: Core Qualifica			
	Theoretical Mechanical Engineering: Technical Compleme		iry	
	Theoretical Mechanical Engineering: Core Qualification: El	ective Compulsory		

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

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Courses				
Title		Тур	Hrs/wk	СР
Technology Management (L0849) Technology Management Seminar	1.0850)	Project-/problem-based Learning Project-/problem-based Learning		3
		Project-/problem-based Leaning	Z	2
	Prof. Cornelius Herstatt			
Admission Requirements				
Kecommended Previous Knowledge	Bachelor knowledge in business management			
-	After taking part successfully, students have rea	ched the following learning results		
Professional Competence	The taking pure successionly, statenes have rea			
-	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies			
	 Technology Strategies and Lifecycl Technology Intelligence and Planni 	- · · ·		
	Technology Portfolio Management	ig		
	Technology Portfolio Management Technology Portfolio Methodology			
	 Technology Acquisition and Exploit 	ation		
	• IP Management			
	Organizing Technology Development			
	 Technology Organization & Manage 	ement		
	 Technology Funding & Controlling 			
Skills	The course aims to:			
	 Develop an understanding of the important 	nce of Technology Management - on a national	as well as inter	national level
		of important elements of Technology Ma		
	organizational and process-related aspect		5	5 1
	Foster a strategic orientation to problem	solving within the innovation process as well	as Technology	Management and
	importance for corporate strategy			
	Clarify activities of Technology Manageme	ent (e.g. technology sourcing, maintenance and	l exploitation)	
		lls and a basic understanding of managerial,		and financial iss
	concerning Technology-, Innovation- and	R&D-management. Further topics to be discuss	ed include:	
	 Basic concepts, models and tools, relevant 	t to the management of technology, R&D and i	nnovation	
	Innovation as a process (steps, activities a	and results)		
Personal Competence				
Social Competence	Interact within a team			
	 Raise awareness for globabl issues 			
Autonomy	Gain access to knowledge sources			
		ntext of Technology and Innovation Manageme	nt	
	Develop presentation skills			
	Discussion of international cases in R&D-1	lanagement		
Workload in Hours	Independent Study Time 110, Study Time in Lec	ture 70		
Credit points	6			
Course achievement				
Examination				
Examination duration and	90 minutes			
scale	Clabel Internation Management Court Court			
-	Global Innovation Management: Core Qualification		manulaa	
Following Curricula	International Management and Engineering: Spec	-	mpulsory	
	Mechanical Engineering and Management: Speci Biomedical Engineering: Specialisation Artificial		mpulsory	
	Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implants		inpuisory	
	Biomedical Engineering: Specialisation Medical T		lsorv	
	Biomedical Engineering: Specialisation Managen			

Course L0849: Technology M	lanagement
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	The role of technology for the competitive advantage of the firm and industries; Basic concepts, models and tools for the management of technology; managerial decision making regarding the identification, selection and protection of technology (make or buy, keep or sell, current and future technologies). Theories, practical examples (cases), lectures, interactive sessions and group study. This lecture is part of the Module Technology Management and can not separately choosen.
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	lanagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Courses						
Courses				-	11	
Title Microsystems Technology (L0724)				Typ Lecture	Hrs/wk	CP 4
Microsystems Technology (L0725)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous	Basics in physics, che	mistry, mechanics and s	semiconductor techn	ology		
Knowledge						
	After taking part succ	essfully, students have	reached the following	g learning results		
Professional Competence	Students are able					
Knowieage	Students are able					
				or microstructures and especia of in more complex systems	Illy methods f	for the fabrication
	• to explain in deta	ils operation principles o	of microsensors and	microactuators and		
	 to discuss the po 	tential and limitation of	microsystems in app	lication.		
Skills	Students are capable					
	 to analyze the feature 	asibility of microsystems	5,			
		ss flows for the fabricati		s and		
				5 and		
	 to apply them. 					
Personal Competence Social Competence						
	Students are able to of audience.	prepare and perform the	eir lab experiments ir	n team work as well as to prese	ent and discus	ss the results in fro
Autonomy	None					
Workload in Hours	Independent Study Ti	me 124, Study Time in I	Lecture 56			
Credit points	6					
Course achievement	Compulsory Bonus Yes None	Form Subject theoretical practical work		führen in Kleingruppen ein La d diskutiert die Theorie sowie o nten Kurs.		
Examination	Oral exam					
Examination duration and	30 min					
scale	Electrical Engineers'	Coocialization Name	stropics and Misse	retome Tochnology, Election Co	mulcon	
-		: Specialisation Nanoele : Specialisation Medical		vstems Technology: Elective Co e Compulsory	привогу	
ytulu		•	•••	hatronics: Elective Compulsory		
	-			nerative Medicine: Elective Com		
	-			ses: Elective Compulsory		
	-	•		ontrol Theory: Elective Compuls	-	
	DIOMEQUCAL ENGINEERI	ng. specialisation Mahag	yemenic and Business	Administration: Elective Comp	uisuiy	

Course L0724: Microsystems	Technology		
-	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	ndependent Study Time 92, Study Time in Lecture 28		
Lecturer	Prof. Hoc Khiem Trieu		
Language	EN		
Cycle	WiSe		
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SUB, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: (strain based and stress based principle, capacitive readout, piezoresistivy, pressure sensor: piezoresistive, capacitive and fabrication process) Mechanical Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensor: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellibro and thermal conductivity sensor; metal oxide semiconductor gas sensor, Jambad group, Lamode, Lamode, MorsFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps		
	relationship) • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)		
	M. Madeur Fundemantela of Minurfelariation, CDC Datas, 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		

Course L0725: Microsystems	ourse L0725: Microsystems Technology		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	ndependent Study Time 32, Study Time in Lecture 28		
Lecturer	of. Hoc Khiem Trieu		
Language	l		
Cycle	liSe		
Content	ee interlocking course		
Literature	See interlocking course		

Courses				
Courses		-		
Title Control Systems Theory and Desigr	(10656)	Typ Lecture	Hrs/wk 2	CP 4
Control Systems Theory and Design		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
	Introduction to Control Systems			
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge				
		ynamic systems are represented as state space	models; they can	interpret the sys
		al excitation as trajectories in state space erties controllability and observability, and their re	lationship to stat	a foodback and a
	estimation, respectively	erties controllability and observability, and then re		
	 They can explain the significance of 	f a minimal realisation		
		tate feedback and how it can be used to achieve tr	acking and distur	bance rejection
	They can extend all of the above to	o multi-input multi-output systems		
	• They can explain the z-transform a	nd its relationship with the Laplace Transform		
	 They can explain state space mode 	els and transfer function models of discrete-time sy	stems	
	 They can explain the experimental 	identification of ARX models of dynamic systems,	and how the iden	tification problem
	be solved by solving a normal equa			
	 They can explain how a state space 	e model can be constructed from a discrete-time in	npulse response	
Skills				
		nction models into state space models and vice ver	rsa	
	 They can assess controllability and observability and construct minimal realisations They can design LOG controllers for multivariable plants 			
	 They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropria 			
	for a given sampling rate			
	 They can identify transfer function models and state space models of dynamic systems from experimental data 			
	• They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox			
	Simulink)			
Personal Competence				
	Students can work in small groups on spe	cific problems to arrive at joint solutions		
boelar competence				
Autonomy		rovided sources (lecture notes, software documer	itation, experime	nt guides) and u
	when solving given problems.			
	They can assess their knowledge in week	ly on-line tests and thereby control their learning p	rogress.	
			-	
	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Electrical Engineering: Core Qualification:	Compulsory		
Following Curricula	Energy Systems: Core Qualification: Elect			
	Aircraft Systems Engineering: Specialisati			
	Aircraft Systems Engineering: Specialisati			
		Specialisation II. Engineering Science: Elective Com		
		ng: Specialisation II. Electrical Engineering: Elective		
		ng: Specialisation II. Mechatronics: Elective Compul :: Specialisation Mechatronics: Elective Compulsory		
	Mechatronics: Core Qualification: Computer			
		sory tificial Organs and Regenerative Medicine: Elective	Compulsory	
		plants and Endoprostheses: Elective Compulsory	Compuisory	
		edical Technology and Control Theory: Compulsory		
	• • •	anagement and Business Administration: Elective C		
		uction: Core Qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Core			

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

Course L0657: Control Systems Theory and Design		
Тур	itation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28	
Lecturer	of. Herbert Werner	
Language		
Cycle	iSe	
Content	ee interlocking course	
Literature	e interlocking course	

Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0932)	2020)	Lecture	2	2
Production Planning and Control (L Production Planning and Control (L		Lecture Recitation Section (small)	2	2 1
Exercise: The Digital Enterprise (LO		Recitation Section (small)	1	1
	Prof. Hermann Lödding	Neerador Section (Sindir)	-	-
Admission Requirements				
	Fundamentals of Production and Quality M	lanagement		
Knowledge				
	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the r	nodule in detail and take a critical position to them.		
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
, Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineerin	g: Specialisation II. Product Development and Produ	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spec	cialisation Production and Logistics: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Me	dical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration: Compulsor	у	
	Product Development, Materials and Produ	uction: Specialisation Product Development: Elective	e Compulsory	
	Product Development, Materials and Produ	uction: Specialisation Production: Compulsory		
	Product Development, Materials and Produ	uction: Specialisation Materials: Elective Compulsor	/	
	Theoretical Mechanical Engineering: Speci	ialisation Product Development and Production: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	iterprise
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered. Content: • Business Process Management and Data Modelling, Simulation • Knowledge and Competence Management • Process Management (PPC, Workflow Management) • Computer Aided Planning (CAP) and NC-Programming • Virtual Reality (VR) and Augmented Reality (AR) • Computer Aided Quality Management (CAQ) • Industry 4.0
Literature	Scheer, AW.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002 Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006 Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004 Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007 Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006

Course L0929: Production Pla	ourse L0929: Production Planning and Control		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	 Models of Production and Inventory Management Production Programme Planning and Lot Sizing Order and Capacity Scheduling Selected Strategies of PPC Manufacturing Control Production Controlling Supply Chain Management 		
Literature	 Vorlesungsskript Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002 		

Course L0930: Production Pl	ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0933: Exercise: The	Digital Enterprise
Тур	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	Siehe korrespondierende Vorlesung
	See interlocking course

	ronic Circuits for M					
Courses						
Title Electronic Circuits for Medical Applications (L0696) Electronic Circuits for Medical Applications (L1056) Electronic Circuits for Medical Applications (L1408)				Typ Lecture Recitation Section (small) Practical Course	Hrs/wk 2 1 1	CP 3 2 1
Module Responsible				Tractical course	Ŧ	Ŧ
Admission Requirements						
Recommended Previous	Fundamentals of electrical	engineering				
Knowledge	After taking part successful	v students have r	eached the follow	ing learning results		
Professional Competence	Arter taking part succession	y, students nave i	cachea the follow	ing learning results		
Knowledge	 Students can explair Students are able to Students can exemp Students can describ Students can explair 	explain the build-u ify the communica e the special featu the functions of p	p of an action pot tion between neu res of low-noise a rostheses, e. g. ar	ation transfer by the central cential and its propagation alc rons and electronic devices mplifiers for medical applicat a artificial hand of cochlea implants and artif	ong an axon	
Skills	Students can give scStudents can develop	enarios for further p the block diagra	improvement of long to the second sec	avior of an action potential ow-noise and low-power signa ystems ems for an articifial eye.	al acquisition.	
Personal Competence Social Competence	 Students are trained professional backgrd Students are able to 	und. recognize their spe ent their work in a	ecific limitations, s	medical electronics in teams to that they can ask for assist ad communicate their results	tance to the right	time.
Autonomy	necessary. • Students can break o • Students can handle	lown their work in the complex data	appropriate work structures of bioel	their knowledge and to de packages and schedule their lectrical experiments without ses and situations of experim	work in a realistic needing support.	: way.
Workload in Hours	Independent Study Time 12	4, Study Time in L	ecture 56			
Credit points	6					
Course achievement	Yes None Sub	ect theoretical tical work ercises	Description and			
Examination						
Examination duration and scale						
Assignment for the Following Curricula	Biomedical Engineering: Sp Biomedical Engineering: Sp Biomedical Engineering: Sp Microelectronics and Micros	ecialisation Artifici ecialisation Implan ecialisation Medica ecialisation Manag ystems: Specialisa	al Organs and Reg ts and Endoprosth Il Technology and ement and Busine tion Microelectror	generative Medicine: Elective	ompulsory ompulsory	

Course L0696: Electronic Cire	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	 Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Course L1056: Electronic Cire	ourse L1056: Electronic Circuits for Medical Applications		
Тур	Recitation Section (small)		
Hrs/wk	1		
CP	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1408: Electronic Cire	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 Market for medical instruments Membrane potential, action potential, sodium-potassium pump Information transfer by the central nervous system Interface tissue - electrode Amplifiers for medical applications, analog-digital converters Examples for electronic implants Artificial eye, cochlea implant
Literature	Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010 Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007 Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/

Module M1150: Conti	nuum Mechanics			
- -				
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533) Continuum Mechanics Exercise (L1	534)	Lecture Recitation Section (small)	2 2	3 3
Module Responsible	1	Rectation Section (Small)		5
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught	e q in the module Mechanics II (forces an	d moments stre	ss linear strain fre
Knowledge	-	•		oo, mear oran, ne
5				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental conce	epts to calculate the mechanical behavior of r	naterials.	
	·			
Skills	The students can set up balance laws and app	ly basics of deformation theory to specific as	spects, both in a	pplied contexts as
	research contexts.			
Personal Competence	-			6 (1)
Social Competence	The students are able to develop solutions, to pr	resent them to specialists in written form and	to develop ideas	s further.
4				
Autonomy	The students are able to assess their own stren problems in the area of continuum mechanics a		-	whildentify and sol
	problems in the area of continuum mechanics a	the acquire the knowledge required to this end	1.	
Workload in Hours	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elect	ive Compulsory		
Following Curricula	Mechanical Engineering and Management: Spec	ialisation Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course	: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial		Compulsory	
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical	•••		
	Biomedical Engineering: Specialisation Manager		ompulsory	
	Product Development, Materials and Production			
	Theoretical Mechanical Engineering: Technical C			
	Theoretical Mechanical Engineering: Core Qualif	ication: Elective Compulsory		

Course L1533: Continuum Me	ourse L1533: Continuum Mechanics		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Christian Cyron		
Language	DE		
Cycle	WiSe		
Content	 kinematics of undeformed and deformed bodies balance equations (balance of mass, balance of energy,) stress states material modelling 		
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer		

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

	rial Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum m	echanics as taught, e.g., in the modules Mechanic	s II and Continuu	um Mechanics (fo
Knowledge	and moments, stress, linear and nonlinear s	strain, free-body principle, linear and nonlinear cor	nstitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws			
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowled			
	to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
Social Competence	etence The students are able to develop solutions, to present them to specialists and to develop ideas further.			
Autonomy		strengths and weaknesses. They can independent and acquire the knowledge required to this end.	y and on their ou	wn identify and s
Workload in Hours	Independent Study Time 124, Study Time ir	n Lecture 56		
Credit points	6			
Course achievement				
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling:	Elective Compulsory		
Following Curricula	Mechanical Engineering and Management:	Specialisation Materials: 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 Management and Business Administration: Elective Compulsory			
	Product Development, Materials and Production: Core Qualification: Elective Compulsory			
	Froduce Development, Materials and Froduce	cion. core quanteation. Elective compaisory		
		lisation Materials Science: Elective Compulsory		

ourse L1535: Material Modeling		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials) - plasticity (permanent deformation due to one-time overload, e.g., in metal forming) - viscoelasticity (absorption of energy, e.g., in dampers) - creep (slow deformation under permanent load, e.g., in pipes)	
	This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.	
Literature		

Course L1536: Material Mode	urse L1536: Material Modeling	
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

	nced Functional Materials			
Courses				
Title		Тур	Hrs/wk	СР
Advanced Functional Materials (L1	525)	Seminar	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.	g. Materials Science I/II		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particul metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.			
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design nermaterials considering architectural principles from the micro- to the macroscale. The students will also gain an overview of modern materials science, which enables them to select optimum materials combinations depending on the technical applications.			
Personal Competence				
Social Competence	The students are able to present solution	ns to specialists and to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and we 	eaknesses.		
	 gather new necessary expertise b 	y their own.		
Workload in Hours	Independent Study Time 152, Study Tim	e in Lecture 28		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Materials Science: Core Qualification: Co	mpulsory		
Following Curricula	Mechanical Engineering and Managemen	nt: Specialisation Materials: Elective Compulso	ry	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Ele	active Compulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprostheses: Elective Compuls	sory	
	Biomedical Engineering: Specialisation N	ledical Technology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation N	lanagement and Business Administration: Elec	tive Compulsory	
		hnical Complementary Course: Elective Compu		
	Theoretical Mechanical Engineering: Spe	cialisation Materials Science: Elective Compuls	sory	

Course L1625: Advanced Functional Materials		
Тур	Seminar	
Hrs/wk	2	
СР	6	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Christian Cyron, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Stefan Fritz Müller	
Language	DE	
Cycle	WiSe	
Content	1. Porous Solids - Preparation, Characterization and Functionalities	
	2. Fluidics with nanoporous membranes	
	3. Thermoplastic elastomers	
	4. Optimization of polymer properties by nanoparticles	
	5. Fiber composites in automotive	
	6. Modeling of materials based on quantum mechanics	
	7. Biomaterials	
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.	

Module M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
-	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
5	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	-	Lecture	2	3
Experimental Methods for the Char		Lecture	2	3
Numerical Methods in Biomechanic		Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective (Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsorv	

Course L1663: Nature's Hiera	archical Materials
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	
scale	
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a
	diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological
	materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic
	function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc. This lecture will focus on materials
	with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea),
	mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of
	the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334
	Journal publications

Course L1669: Introduction t	to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits
	 Fundamental properties and phenomena of electrical circuits Steady-state sinusoidal analysis of electromagnetic fields and waves Steady-state sinusoidal description of electromagnetic fields and waves Useful microwave network parameters Transmission lines and basic results from transmission line theory Plane wave propagation, superposition, reflection and refraction General theory of waveguides and their properties Radiation and basic antenna parameters Most important types of antennas and their properties Numerical techniques and CAD tools for waveguide and antenna design Fundamentals of Electromagnetic Compatibility Coupling mechanisms and countermeasures Shielding, grounding, filtering Standards and regulations EMC measurement techniques
Literature	 Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) D. M. Pozar, "Microwave Engineering", Wiley (2011) Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Course L1588: Development	and Regulatory Approval of Implants
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	 E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	 Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011). William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).

Course L1583: Numerical Methods in Biomechanics		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	 Vorkenntnisse aus " Diskretisierungsmethoden der Mechanik" sind empfohlen Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult. 	
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009	

Course L1890: Seminar Biomedical Engineering		
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

Course L1130: Six Sigma	
Тур	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Claus Emmelmann
Language	
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008

ourse L0001: Fluid Mechan Typ	Lecture
Hrs/wk	
CP	
Workload in Hours	
Examination Form	Klausur
Examination duration and	
scale	Desf Mishes I Cablifier
Lecturer	
Language	
Cycle	WiSe
Content	Differential equations for momentum-, heat and mass transfer
	 Examples for simplifications of the Navier-Stokes Equations
	Unsteady momentum transfer
	Free shear layer, turbulence and free jets
	Flow around particles - Solids Process Engineering
	Coupling of momentum and heat transfer - Thermal Process Engineering
	Rheology – Bioprocess Engineering
	 Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering
	 Flow threw porous structures - heterogeneous catalysis
	Wind- and Wave-Turbines - Renewable Energy
	Introduction into Computational Fluid Dynamics
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.
	 Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	 Broder, H., Newes, D.: Standastadast emschilesiner tremsener reaktion. Frankfart: Saderhander 2572. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.
	 Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg
	2006.
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	 Fox, R.W., et al., infoundation to Fund Mechanics. J. Whey & Sons, 1994. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunger
	Springer Verlag, Berlin, Heidelberg, New York, 2006.
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW Fachverlage GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	 Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner GWV Fachverlage GmbH, Wiesbaden, 2009.
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.
	 Schade, M., Kalle, E.: Schnangsteiner, Verlag de Grayter, Schin, Kein Von, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe Verlag, Berlin, Heidelberg, 2008.
	12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.
	12. Schilchung, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006. 13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.
	25. Tal. 2 yee, yar yaban of third Ploton. The Fundbolic (1655, Stafford California, 1662.

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
	OpenModelica. Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example:Hydraulic systems and heat transfer Example: System with different subsystems
Literature	 Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7 M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014. M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german) Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000. P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015. P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.

Course L1821: System Simul	ation
Тур	Recitation Section (large)
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0379: Ceramics Tecl	hnology		
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
	Dr. Rolf Janßen		
Language			
Cycle			
Content	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on pow		
		-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass new developments in powderless forming techniques of ceramics and ceramic composites will be	
		iscussed in order to give engineering students an understanding of technology development and	
	specific applications of ceramic components.		
	Content:	1. Introduction	
	Inhalt:	2. Raw materials	
		3. Powder fabrication	
		4. Powder processing	
		5. Shape-forming processes	
		6. Densification, sintering	
		7. Glass and Cement technology	
		8. Ceramic-metal joining techniques	
Literature	W.D. Kingery, "Introduction to C	Ceramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials Hand	dbook Vol.4 "Ceramics and Glasses", 1991	
	D.W. Richerson, "Modern Ceram	nic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

Courses				
Courses				
Title Introduction to Biochemistry and M	alocular Piology (L0296)	Typ Lecture	Hrs/wk	CP 3
	Prof. Hans-Jürgen Kreienkamp	Lecture	2	5
Admission Requirements	None			
Recommended Previous Knowledge	None			
	After taking part successfully, students	have reached the following learning results		
Professional Competence	Arter taking part successiony, students	have reached the following learning results		
-	The students can			
Kilowieuge				
	 describe basic biomolecules; 			
	 explain how genetic information i 	s coded in the DNA;		
	 explain the connection between I 	DNA and proteins;		
Skills	The students can			
JKIIIS				
	 recognize the importance of mole 	cular parameters for the course of a disease;		
	 describe selected molecular-diage 	nostic procedures;		
	 explain the relevance of these pressure 	ocedures for some diseases		
Personal Competence				
	The students can participate in discussion	ons in research and medicine on a technical lev	vel.	
Autonomy	The students can develop understanding	g of topics from the course, using technical lite	rature, by themselves.	
Workload in Hours	Independent Study Time 62, Study Time	e in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German p	rogram, 7 semester): Specialisation Biomedica	I Engineering: Compulsory	,
Following Curricula	General Engineering Science (German	n program, 7 semester): Specialisation Med	chanical Engineering, Foc	us Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: C	Compulsory		
	Electrical Engineering: Specialisation Me	edical Technology: Elective Compulsory		
	Engineering Science: Specialisation Bior	nedical Engineering: Compulsory		
	General Engineering Science (English pr	ogram, 7 semester): Specialisation Biomedical	Engineering: Compulsory	
	General Engineering Science (English	program, 7 semester): Specialisation Mec	hanical Engineering, Foc	us Biomechani
	Compulsory			
	Mechanical Engineering: Specialisation I	Biomechanics: Compulsory		
	Biomedical Engineering: Specialisation	Management and Business Administration: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation A	Artificial Organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprostheses: Elective Compute	sory	
	Technomathematics: Specialisation III. E	ngineering Science: Elective Compulsory		

Course L0386: Introduction t	to Biochemistry and Molecular Biology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008

Courses				
Title		Тур	Hrs/wk	СР
Implants and Fracture Healing (L03	76)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Introduction	into Anatomie" before attending "Imp	plants and Fracture Heali	ing".
Knowledge				
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how	v bones heal, and the requirements for	or their existence.	
	The students can name different treatments for t	he spine and hollow bones under give	en fracture morphologies	
CL ///-	The state of the second state of the forest state of the second st			6
SKIIIS	The students can determine the forces acting wit	nin the human body under quasi-stat	ic situations under speci	ne assumptions.
Personal Competence				
Social Competence	The students can, in groups, solve basic numeric	al modeling tasks for the calculation o	of internal forces.	
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
Autonomy	The students can, in groups, solve basic numeric		or internal forces.	
Workload in Hours	Independent Study Time 62, Study Time in Lectu	re 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program	m, 7 semester): Specialisation Me	chanical Engineering, F	ocus Biomechan
Following Curricula	Compulsory			
	General Engineering Science (German program,	•	al Engineering: Compulso	ory
	Engineering Science: Specialisation Biomedical E			
	General Engineering Science (English program, 7	semester): Specialisation Biomedical	Engineering: Compulsor	ry .
	General Engineering Science (English program	n, 7 semester): Specialisation Mee	chanical Engineering, F	ocus Biomechan
	Compulsory			
	Mechanical Engineering: Specialisation Biomecha	nics: Compulsory		
	Biomedical Engineering: Specialisation Artificial C	organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants a	and Endoprostheses: Elective Compul	sory	
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Managem	ent and Business Administration: Elec	tive Compulsory	
	Orientierungsstudium: Core Qualification: Elective			
	Technomathematics: Specialisation III. Engineerin			

	Fracture Healing
Тур	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Language	
Cycle	Topics to be covered include:
	1. Introduction (history, definitions, background importance)
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)
	3.1 The spine in its entirety
	3.2 Cervical spine
	3.3 Thoracic spine
	3.4 Lumbar spine
	3.5 Injuries and diseases
	4. Pelvis (anatomy, biomechanics, fracture treatment)
	5 Fracture Healing
	5.1 Basics and biology of fracture repair
	5.2 Clinical principals and terminology of fracture treatment
	5.3 Biomechanics of fracture treatment
	5.3.1 Screws
	5.3.2 Plates
	5.3.3 Nails
	5.3.4 External fixation devices
	5.3.5 Spine implants
	6.0 New Implants
Literature	Cochran V.B.: Orthopädische Biomechanik
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical	techniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	The students can describe the materials of t	he human body and the materials being	used in medical engineer	ing, and their field
	use.			
Skills	The students can explain the advantages ar	d disadvantages of different kinds of bio	materials.	
Personal Competence				
Social Competence	etence The students are able to discuss issues related to materials being present or being used for replacements with student			h student mates a
	the teachers.			
Autonomy	The students are able to acquire information	on their own. They can also judge the in	formation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in I	ecture 28		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and I	lybrid Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Impl	ants and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medi			
	Biomedical Engineering: Specialisation Mana	-		
	Theoretical Mechanical Engineering: Technic	1 5		
	Theoretical Mechanical Engineering: Special	sation Bio- and Medical Technology: Elec	ctive Compulsory	

Course L0593: Biomaterials	
Тур	
Hrs/wk	
CP Workload in Hours	
Lecturer	
Language	
Cycle	WiSe
Content	Topics to be covered include:
	1. Introduction (Importance, nomenclature, relations)
	2. Biological materials
	2.1 Basics (components, testing methods)
	2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.

	e Elements Methods			
Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2 2	3 3
Finite Element Methods (L0804)		Recitation Section (large)	Z	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mecha Mathematics I, II, III (in particular differential equations)	nics II (Hydrostatics, Kinematics, Dyna	amics)	
Kilowieuge	Mathematics I, II, III (III particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge regardin overview of the theoretical and methodical basis of the r		ent method and a	are able to give
Skills	The students are capable to handle engineering proble system matrices, and solving the resulting system of equ		ments, assembling	g the correspondi
	Students can work in small groups on specific problems The students are able to independently solve challen		levelop own finite	e element routin
Workland in Hause	Independent Study Time 124, Study Time in Lecture 56			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6 Compulsory Bonus Form Descr	intion		
Course achievement	No 20 % Midterm	pton		
Examination				
Examination duration and	120 min			
scale				
	Civil Engineering: Core Qualification: Compulsory			
Assignment of the		/		
Following Curricula				
-	Aircraft Systems Engineering: Specialisation Aircraft Systems	tems: Elective Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft Sys Aircraft Systems Engineering: Specialisation Aircraft Sys			
-		tems: Elective Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft Sys	tems: Elective Compulsory rtation Systems: Elective Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft Sys Aircraft Systems Engineering: Specialisation Air Transpo	tems: Elective Compulsory rtation Systems: Elective Compulsory rtation Systems: Elective Compulsory		
-	Aircraft Systems Engineering: Specialisation Aircraft Sys Aircraft Systems Engineering: Specialisation Air Transpo Aircraft Systems Engineering: Specialisation Air Transpo	tems: Elective Compulsory rtation Systems: Elective Compulsory rtation Systems: Elective Compulsory on II. Mechatronics: Elective Compulso	ory	
-	Aircraft Systems Engineering: Specialisation Aircraft Sys Aircraft Systems Engineering: Specialisation Air Transpo Aircraft Systems Engineering: Specialisation Air Transpo International Management and Engineering: Specialisati International Management and Engineering: Specialisati International Management and Engineering: Specialisati	tems: Elective Compulsory rtation Systems: Elective Compulsory rtation Systems: Elective Compulsory on II. Mechatronics: Elective Compulso on II. Mechatronics: Elective Compulso on II. Product Development and Produ	ory ory iction: Elective Co	
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Course L0291: Finite Elemen	it Methods
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering
	- Displacement method
	- Hybrid formulation
	- Isoparametric elements
	- Numerical integration
	- Solving systems of equations (statics, dynamics)
	- Eigenvalue problems
	- Non-linear systems
	- Applications
	- Programming of elements (Matlab, hands-on sessions)
	- Applications
Literature	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M1342: Polyr	ners			
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polyme	ers (L0389)	Lecture	2	3
Processing and design with polyme	ers (L1892)	Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements				
	Basics: chemistry / physics / material sci	ence		
Knowledge				
Educational Objectives	After taking part successfully, students r	nave reached the following learning results		
Professional Competence	Students can use the knowledge of plast	ics and define the necessary testing and analy		
Knowledge	Students can use the knowledge of plast	ics and define the necessary testing and analys	515.	
	They can explain the complex relationsh	ips structure-property relationship and		
	the interactions of chemical structure of	the polymers, including to explain neighboring	contexts (e.g. sustaina	ability. environment
	protection).	· · · · · · · · · · · · · · · · · · ·		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
<i></i>				
Skills	Students are capable of			
	- using standardized calculation method	ods in a given context to mechanical proper	ties (modulus, streng	th) to calculate a
	evaluate the different materials.			
	- selecting appropriate solutions for med	chanical recycling problems and sizing example	stiffness, corrosion re	sistance.
Personal Competence				
Social Competence	Students can			
	- arrive at funded work results in heterog	genius groups and document them.		
	provide appropriate feedback and bane	lle feedback en their own performance constru	stivoly	
	- provide appropriate reedback and nanc	lle feedback on their own performance construc	cuvery.	
Autonomy	Students are able to			
, laconomy				
	- assess their own strengths and weakne	esses.		
	- assess their own state of learning in sp	ecific terms and to define further work steps on	this basis.	
	access passible consequences of their -			
	- assess possible consequences of their p	Storessional activity.		
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
-	Materials Science: Specialisation Engine	•		
Following Curricula	·	nplants and Endoprostheses: Compulsory	ative Computer	
	5 5 1	rtificial Organs and Regenerative Medicine: Ele lanagement and Business Administration: Elect	1 3	
		ledical Technology and Control Theory: Elective		
		duction: Specialisation Production: Elective Con		
		duction: Specialisation Materials: Elective Comp		
	Product Development, Materials and Pro	duction: Specialisation Product Development: E	lective Compulsory	
	Theoretical Mechanical Engineering: Tec	hnical Complementary Course: Elective Compu	lsory	
	Theoretical Mechanical Engineering: Spe	cialisation Materials Science: Elective Compulse	ory	

Course L0389: Structure and	Departies of Delymout
	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Dr. Hans Wittich
Language	
Cycle	
	- Structure and properties of polymers
	 Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution Morphology amorph, crystalline, blends Properties
	Elasticity, plasticity, viscoelacity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Processing an	nd design with polymers
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich
Language	DE/EN
Cycle	WiSe
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Moulding; Thermoforming, Foaming; Joining
	Designing with Polymers: Materials Selection; Structural Design; Dimensioning
Literature	Osswald, Menges: Materials Science of Polymers for Engineers, Hanser Verlag
	Crawford: Plastics engineering, Pergamon Press
	Michaeli: Einführung in die Kunststoffverarbeitung, Hanser Verlag
	Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag

Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347)		`	Seminar	2	3
Lecture Tissue Engineering - Reger)	Seminar	2	3
Module Responsible					
Admission Requirements					
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part succ	essfully, students have r	eached the following learning results		
Professional Competence			u dente util he ekte te desetihe the kee		
Knowledge			udents will be able to describe the bas methods of tissue engineering. They are		
	the cultivation of anir		methous of tissue engineering. They are	e able to give a basic ovi	erview of methods
	The students can o	utline the actual conce	pts of Tissue Engineering and regener	rative medicine and ca	n explain the bas
	udnerlying principles	of the discussed topics.			
CI-III-	A 64		danta ana		
SKIIIS	After successful comp	letion of the module stu	dents are		
	 able to use me 	dical databases for acqu	irierung and presentation of relevant up-	to-date data independe	ntly
	able to present their work results in the form of presentations				
	 able to carry o 	ut basic cell culture meth	nods and the corresponding analysis inde	ependently	
	 able to analyse 	and evaluate current re	esearch topics for Tissue Engineering and	l regenerative medicine.	
Personal Competence					
Social Competence	Students are able to	work together as a team	with 2-4 students to solve given tasks a	nd discuss their results	in the plenary and
	defend them.				
	Chudaata aya akia ta				
	Students are able to	effect their work orally a	nd discuss it with other students and tea	icners.	
Autonomy					
Autonomy					
	After completion of	this module, participar	nts will be able to solve a technical	problem in teams of	approx. 2-4 perso
	independently includi	ng a presentation of the	results.		
Workload in Hours	Independent Study Ti	me 124, Study Time in L	ecture 56		
Credit points					
Course achievement		Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pr	rotocol for lecture series	
Examination	Presentation				
Examination duration and	Oral presentation + c	iscussion (30 min)			
scale					
Assignment for the	Biomedical Engineeri	ng: Specialisation Implan	ts and Endoprostheses: Elective Compul	sory	
Following Curricula	Biomedical Engineeri	ng: Specialisation Artifici	al Organs and Regenerative Medicine: Co	ompulsory	
	Biomedical Engineeri	ng: Specialisation Manag	ement and Business Administration: Elec	ctive Compulsory	
	Biomedical Engineeri	ng: Specialisation Medica	al Technology and Control Theory: Electiv	o Compulson	

Course L0347: Regenerative	Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
	The course deals with the application of biotechnological engineering principles for re-generation of human tissues. The main topics are "tissue engineering" for the generation of "artificial organs" such as cartilage, liver, blood vessel etc., and their applications: • Introduction (historical development, examples for medical and technical applications, commercial aspets) • Cell specific fundamentals (cell physiology, biochemistry, metabolism, special requirements for cell cultivation "in vitro") • Process specific fundamentals (requirements for culture systems, examples for reactor design, mathematical modelling, process and control strategies) • Examples for applications for clinical applications, drug testing and material testing The fundamentals will be presented by the lecturers. The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Course L1664: Lecture Tissu	e Engineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978- 0123693716 Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978- 3540777540

Courses						
Title				Тур	Hrs/wk	СР
Robotics and Navigation in Medicir	e (L0335)			Lecture	2	3
Robotics and Navigation in Medicir	e (L0338)			Project Seminar	2	2
Robotics and Navigation in Medicir	e (L0336)			Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schl	laefer				
Admission Requirements	None					
Recommended Previous	 principles of r 	math (algebra, analy	(sis/calculus)			
Knowledge		programming, e.g., i				
	 solid R or Mat 					
Educational Objectives	After taking part suc	ccessfully, students	have reached the follow	ving learning results		
Professional Competence						
Knowledge				n clinical contexts and illustra		
	-			etection and safety and reg	ulations. Students	s can assess typic
	systems regarding d	design and limitatio	ns.			
Skills	The students are ab	le to design and eva	aluate navigation syster	ns and robotic systems for me	dical applications	
Personal Competence						
Social Competence	The students discuss	s the results of othe	r groups, provide helpfu	Il feedback and can incoorpora	ate feedback into	their work.
Autonomy		eflect their knowled	ge and document the re	esults of their work. They can	present the resu	lts in an appropria
	manner.					
Workload in Hours	Independent Study 7	Time 110, Study Tin	ne in Lecture 70			
Credit points	6					
	Compulsory Bonus	Form	Description			
Credit points		Form Written elaborat	-			
Credit points	Compulsory Bonus		-			
Credit points Course achievement Examination	CompulsoryBonusYes10 %	Written elaborat	-			
Credit points Course achievement	CompulsoryBonusYes10 %Yes10 %	Written elaborat	-			
Credit points Course achievement Examination Examination duration and scale	CompulsoryBonusYes10 %Yes10 %Written exam90 minutes	Written elaborat Presentation	ion			
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes Computer Science: Scienc	Written elaborat Presentation Specialisation II: Inte	ion elligence Engineering: E			
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes Computer Science: Selectrical Engineerin	Written elaborat Presentation Specialisation II: Inte g: Specialisation Me	ion elligence Engineering: E edical Technology: Elect	ive Compulsory		
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes Computer Science: S 5 Electrical Engineerin 10 International Manage 10	Written elaborat Presentation Specialisation II: Inteng: Specialisation Mo ement and Enginee	ion elligence Engineering: E edical Technology: Elect ring: Specialisation II. El	ive Compulsory lectrical Engineering: Elective		
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes Computer Science: S Electrical Engineerin International Manage International Manage International Manage	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee ement and Enginee	ion elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotec		Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage Mechatronics: Special	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee ement and Enginee alisation Intelligent	ion elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics:	ive Compulsory lectrical Engineering: Elective rocess Engineering and Bioteck Elective Compulsory	nnology: Elective	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage Mechatronics: Special Biomedical Engineerin Electrical Engineerin	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee ement and Enginee alisation Intelligent ring: Specialisation A	elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotec Elective Compulsory generative Medicine: Elective (nnology: Elective	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage Mechatronics: Special Biomedical Engineer Biomedical Engineer	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee ement and Enginee ialisation Intelligent ring: Specialisation / ring: Specialisation /	elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re mplants and Endoprost	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotech Elective Compulsory generative Medicine: Elective O heses: Elective Compulsory	nnology: Elective Compulsory	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage International Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee lalisation Intelligent ring: Specialisation I ring: Specialisation I ring: Specialisation I	elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re- mplants and Endoprost Medical Technology and	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotect Elective Compulsory generative Medicine: Elective C heses: Elective Compulsory Control Theory: Elective Com	nnology: Elective Compulsory pulsory	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage International Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee alisation Intelligent ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I	ion elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re mplants and Endoprost Medical Technology and Management and Busin	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotect Elective Compulsory generative Medicine: Elective C heses: Elective Compulsory Control Theory: Elective Com ess Administration: Elective Co	nnology: Elective Compulsory pulsory pmpulsory	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage International Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineering Biomedical Engineering Biomedical Engineering Biomedical Engineering Biomedical Engineering	Written elaborat Presentation Specialisation II: Inte ng: Specialisation Me ement and Enginee alisation Intelligent ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I	ion elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re- mplants and Endoprost Medical Technology and Management and Busin- pduction: Specialisation	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotect Elective Compulsory generative Medicine: Elective C heses: Elective Compulsory Control Theory: Elective Com ess Administration: Elective Co Product Development: Elective	nnology: Elective Compulsory pulsory ompulsory e Compulsory	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage International Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin	Written elaborat Presentation Specialisation II: Inte ag: Specialisation Me ement and Enginee element and Enginee alisation Intelligent ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I nt, Materials and Pro	elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re mplants and Endoprost Medical Technology and Management and Busin duction: Specialisation duction: Specialisation	ive Compulsory lectrical Engineering: Elective of rocess Engineering and Biotect Elective Compulsory generative Medicine: Elective of heses: Elective Compulsory I Control Theory: Elective Com ess Administration: Elective Com Product Development: Elective Production: Elective Compulso	nnology: Elective Compulsory pulsory e Compulsory e Compulsory ry	Compulsory
Credit points Course achievement Examination Examination duration and scale Assignment for the	Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes 90 minutes Electrical Engineerin International Manage International Manage International Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin Product Developmerical Engineerin Biomedical Engineerin	Written elaborat Presentation Specialisation II: Inte ag: Specialisation Me ement and Enginee alisation Intelligent ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I ring: Specialisation I nt, Materials and Pro nt, Materials and Pro	elligence Engineering: E edical Technology: Elect ring: Specialisation II. El ring: Specialisation II. Pi Systems and Robotics: Artificial Organs and Re- mplants and Endoprost Medical Technology and Management and Busin- duction: Specialisation duction: Specialisation duction: Specialisation	ive Compulsory lectrical Engineering: Elective rocess Engineering and Biotect Elective Compulsory generative Medicine: Elective C heses: Elective Compulsory Control Theory: Elective Com ess Administration: Elective Co Product Development: Elective	nnology: Elective Compulsory pulsory e Compulsory e Compulsory ry	Compulsory

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

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

Course L0336: Robotics and	Navigation in Medicine
Тур	Recitation Section (small)
Hrs/wk	1
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

Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in Le	cture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artificia	l Organs and Regenerative Medicine: (Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compu	Ilsory	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elect	ve Compulsory	

Course L1963: Case Studies	Course L1963: Case Studies for Regenerative Medicine and Tissue Engineering		
Тур	Seminar		
Hrs/wk	3		
СР	6		
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42		
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock		
Language	DE		
Cycle	SoSe		
Content			
Literature			

Module M0634: Intro	duction	into Me	edical Technolog	gy and Syster	ns		
Courses							
Title					Тур	Hrs/wk	СР
Introduction into Medical Technolo	gy and Syste	ms (L0342)			Lecture	2	3
Introduction into Medical Technolo	gy and Syste	ms (L0343)			Project Seminar	2	2
Introduction into Medical Technolo	gy and Syste	ms (L1876)			Recitation Section (large)	1	1
Module Responsible	Prof. Alexa	nder Schla	aefer				
Admission Requirements	None						
Recommended Previous	principles	of math (a	lgebra, analysis/calculu	s)			
Knowledge							
	principles	of program	nming, R/Matlab				
Educational Objectives	After takin	g part suc	cessfully, students have	e reached the follow	ing learning results		
Professional Competence							
	The stude	nts can e	xplain principles of me	dical technology, i	ncluding imaging systems,	computer aided s	surgery, and medica
5					atory affairs and standards i		
Skills	The studer	nts are abl	e to evaluate systems a	ind medical devices	in the context of clinical app	olications.	
Personal Competence							
Social Competence	The studer	nts describ	e a problem in medical	technology as a pro	ject, and define tasks that a	re solved in a join	t effort.
Autonomy		nts can ref	flect their knowledge a	nd document the re	sults of their work. They ca	n present the resu	ults in an appropriate
	manner.						
Workload in Hours	Independe	nt Study T	ime 110, Study Time in	Lecture 70			
Credit points	6						
Course achievement	Compulsory	Bonus	Form	Description			
	Yes	10 %	Written elaboration				
	Yes	10 %	Presentation				
Examination	Written ex	Written exam					
Examination duration and	90 minutes	5					
scale							
Assignment for the					pecialisation Biomedical Eng		ory
Following Curricula	-				eering: Elective Compulsory		
	-				ng Science: Elective Compul	sory	
			ualification: Elective Co	1			
		-	g: Core Qualification: El				
	-		Specialisation Biomedi				
					ecialisation Biomedical Engi		
	-				ematics & Engineering Scien		ulsory
			5 5 1		er Science: Elective Compuls	·	
				•	ring Sciences: Elective Com	-	
		-	•		generative Medicine: Elective	Compulsory	
	Biomedica	l Engineer	ing: Specialisation Impla	ants and Endoprosth	neses: Elective Compulsory		
		-	•	•••	Control Theory: Elective Cor		
					ess Administration: Elective (Compulsory	
	Technoma	thematics	Specialisation III. Engir	neering Science: Ele	ctive Compulsory		

Course L0342: Introduction i	nto Medical Technology and Systems
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Course L0343: Introduction i	ourse L0343: Introduction into Medical Technology and Systems		
Тур	Project Seminar		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction i	nto Medical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonli	
Courses	
Title Nonlinear Dynamics (L0702)	TypHrs/wkCPIntegrated Lecture46
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	 Calculus Linear Algebra Engineering Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
-	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms concepts. Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and proced
Personal Competence	stadents are usic to apply existing methods and procesures of nonlinear bynamics and to develop nover methods and proced
	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 themselv
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 Hours
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory
Following Curricula	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 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 Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

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

Courses				
Title		Тур	Hrs/wk	СР
Semiconductor Technology (L0722)	Lecture	4	4
Semiconductor Technology (L0723)	Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science and semiconductor devices			
Knowledge				
Educational Objectives	After taking part successfully, students have reached	I the following learning results		
Professional Competence				
Knowledge				
	Students are able			
	 to describe and to explain current fabrication tee 	hniques for Si and GaAs substrates		
	to discuss in details the relevant fabrication	on processes, process flows and t	the impact thereof o	n the fabrication
	semiconductor devices and integrated circuits and			
	 to present integrated process flows. 			
Skills				
	Students are capable			
	to analyze the impact of process parameters on	the processing results ,		
	 to select and to evaluate processes and 			
	 to develop process flows for the fabrication of set 	miconductor devices		
		internation devices.		
Personal Competence				
Social Competence				
			1	
	Students are able to prepare and perform their lab e of audience.	experiments in team work as well as	to present and discus	ss the results in fro
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 8	4		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronic	s and Microsystems Technology: Ele	ctive Compulsory	
•	Biomedical Engineering: Specialisation Artificial Orga			
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulso	ry	
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Electiv	ve Compulsory	
	Microelectronics and Microsystems: Core Qualification	n: Elective Compulsory		

	r Technology		
Тур	Lecture		
Hrs/wk	4		
СР	1		
Workload in Hours	ndependent Study Time 64, Study Time in Lecture 56		
Lecturer	Prof. Hoc Khiem Trieu		
Language	DE/EN		
Cycle	SoSe		
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, highe order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation or GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic: temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuur evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximit and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique an electroplating, improving resolution: excimer laser light source, immersion lithography, wet chemical etching: isotropic an anisotropic, corner undercuting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, el		
	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons		
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons		
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag		
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag		
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin		
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press		
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill		

Course L0723: Semiconducto	Course L0723: Semiconductor Technology		
Тур	Practical Course		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Hoc Khiem Trieu		
Language	DE/EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Module M0835: Huma	noid Robotics			
Courses				
Fitle Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk	CP 2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge				
j -	 Introduction to control systems 			
	 Control theory and design 			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge				
	Students can explain humanoid robots.	anta fan diffanant taalus in buuranaid u		
	 Students learn to apply basic control conc 	epts for different tasks in numanoid re	DDOUCS.	
Skills				
	Students acquire knowledge about selecte		ed on specified literature	
	Students generalize developed results and			
	 Students practice to prepare and give a prepare and give an	resentation		
Personal Competence				
Social Competence				
	Students are capable of developing solution			
	 They are able to provide appropriate feed 	back and handle constructive criticism	n of their own results	
Autonomy				
	 Students evaluate advantages and draw 	backs of different forms of presenta	ation for specific tasks	and select the be
	solution			
	Students familiarize themselves with a so	cientific field, are able of introduce it	and follow presentation	ns of other studen
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lectu	re 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
•	Mechatronics: Specialisation Intelligent Systems			
Following Curricula	Mechatronics: Specialisation System Design: Elec			
	Biomedical Engineering: Specialisation Artificial (• •		
	Biomedical Engineering: Specialisation Implants		•	
	Biomedical Engineering: Specialisation Medical T			
	Biomedical Engineering: Specialisation Managem			
	Theoretical Mechanical Engineering: Technical Co			
	Theoretical Mechanical Engineering: Specialisation	on Robotics and Computer Science: El	ective Compulsory	

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

Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Classical control (frequency response, r State space methods Discrete-time systems Linear algebra, singular value decompo Basic knowledge about stochastic proce 	sition		
Educational Objectives	After taking part successfully, students have r	eached the following learning results		
Professional Competence		5 5 5		
Knowledge Skills	 Students can explain the general framework of the prediction error method and its application to a variety of linear a nonlinear model structures They can explain how multilayer perceptron networks are used to model nonlinear dynamics They can explain how an approximate predictive control scheme can be based on neural network models They can explain the idea of subspace identification and its relation to Kalman realisation theory 			
	 Students are capable of applying the models for dynamic systems They are capable of implementing a no They are capable of applying subspace They can do the above using standard standa	nlinear predictive control scheme base algorithms to the experimental identifi	d on a neural network mo cation of linear models fo	odel or dynamic systems
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 solve given problems.	in sources provided (lecture notes, lite	erature, software docume	entation) and use it
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale	Electrical Englished in a Constant		. Commulation	
-	Electrical Engineering: Specialisation Control a Mechatronics: Specialisation Intelligent Syster		e Compulsory	
ronowing curricula	Mechatronics: Specialisation Intelligent System Mechatronics: Specialisation System Design: E			
	Biomedical Engineering: Specialisation Artificia		Elective Compulsory	
	Biomedical Engineering: Specialisation Implan	ts and Endoprostheses: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Medica	I Technology and Control Theory: Com	pulsory	
	Biomedical Engineering: Specialisation Manag			
	Theoretical Mechanical Engineering: Technical		pulsory	
	Theoretical Mechanical Engineering: Core Qua	lification: Elective Compulsory		

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

Courses					
Courses					
Title Optimal and Robust Control (L0658		Typ Lecture	Hrs/wk 2	СР 3	
Optimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible			_	-	
Admission Requirements					
Recommended Previous	NOIC				
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	following learning results			
Professional Competence					
Knowledge					
hilomeage	 Students can explain the significance of the matrix 	Riccati equation for the solution of	LQ problems.		
	 They can explain the duality between optimal stat 	1			
	 They can explain how the H2 and H-infinity norms 				
	They can explain how an LQG design problem can		•		
	They can explain how model uncertainty can be r			-	
	 They can explain how - based on the small gain t an uncertain plant 	neorem - a robust controller can gu	arantee stability	and performance	
	an uncertain plant.They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalitie				
				matrix mequality	
Skills	 Students are capable of designing and tuning LQG controllers for multivariable plant models. 				
	 They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard 				
	software tools for solving it.				
	• They are capable of translating time and frequency domain specifications for control loops into constraints on closed-l				
	sensitivity functions, and of carrying out a mixed-sensitivity design.				
	• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-object				
	robust controller.				
	 They are capable of formulating analysis and synthesis 	hesis conditions as linear matrix ine	qualities (LMI), a	nd of using stand	
	LMI-solvers for solving them.				
	 They can carry out all of the above using standard 	software tools (Matlab robust contro	l toolbox).		
Personal Competence					
	Students can work in small groups on specific problems t	o arrive at joint solutions.			
	Students are able to find required information in sources		oftware docume	ntation) and use	
	solve given problems.			,	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
•	Electrical Engineering: Specialisation Control and Power	systems Engineering: Elective Compi	uisory		
Following Curricula	Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Syst	ems: Elective Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Rob				
	Mechatronics: Specialisation Fitteringent Systems and Kot				
	Biomedical Engineering: Specialisation Artificial Organs a		Compulsorv		
	Biomedical Engineering: Specialisation Implants and End	-			
	Biomedical Engineering: Specialisation Medical Technolo		pulsory		
	Biomedical Engineering: Specialisation Management and		-		
	Product Development, Materials and Production: Speciali				
	Product Development, Materials and Production: Speciali	sation Production: Elective Compulso	ory		
	Product Development, Materials and Production: Speciali	sation Materials: Elective Compulsor	/		
	Theoretical Mechanical Engineering: Technical Complement	entary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Core Qualification: E	lective Compulsory			

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

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

Courses				
			Hane hurle	CD
Fitle Marketing of Innovations (L2009)		Typ Lecture	Hrs/wk	CP 4
PBL Marketing of Innovations (L086		Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements				
Recommended Previous				
Knowledge	Module International Business			
	Basic understanding of business administration principle	es (strategic planning, decisio	on theory, pi	roject managem
	international business)	a Markat and Compatitor Strat	ogios Dosiss	of Duning Dobard
	 Bachelor-level Marketing Knowledge (Marketing Instrument Unerstanding the differences beweetn B2B and B2C market 		egies, basics i	or buying benav
	 Understanding of the importance of managing innovation in 			
	Good English proficiency; presentation skills	giobal madocital marketo		
Educational Objectives	After taking part successfully, students have reached the following	J learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innovative porod	ducts and services		
	Approaches for analyzing the current market situation and the		:	
	The gathering of information about future customer needs a	and requirements		
	Concepts and approaches to integrate lead users and their	needs into product and service	development	processes
	Approaches and tools for ensuring customer-orientation in t	he development of new produc	ts and innov <i>a</i>	ative services
	 Marketing mix elements that take into consideration the s 	pecific requirements and chall	enges of inno	ovative products
	services			
	 Pricing methods for new products and services 			
	The organization of complex sales forces and personal sellin			
	 Communication concepts and instruments for new products 	and services		
Skills	Based on the acquired knowledge students will be able to:			
	Design and to evaluate decisions regarding marketing and	innovation strategies		
	Analyze markets by applying market and technology portfo	lios		
	Conduct forecasts and develop compelling scenarios as a background backg	asis for strategic planning		
	 Translate customer needs into concepts, prototypes and r 	narketable offers and successf	ully apply ad	vanced methods
	customer-oriented product and service development			
	Use adequate methods to foster efficient diffusion of innova			
	Choose suitable pricing strategies and communication activ			
	Make strategic sales decisions for products and services (i.e			
	Apply methods of sales force management (i.e. customer value)	alue analysis)		
Personal Competence				
Social Competence	The students will be able to			
	 have fruitful discussions and exchange arguments 			
	 develop original results in a group 			
	 present results in a clear and concise way 			
	carry out respectful team work			
Autonomv	The students will be able to			
· · · · · · · · · · · · · · · · · · ·				
	Acquire knowledge independently in the specific context an		ier new comp	olex problem field
	Consider proposed business actions in the field of marketing	g and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	Written elaboration, excercises, presentation, oral participation			
scale				
Assignment for the	Global Technology and Innovation Management & Entrepreneursh	ip: Core Qualification: Compuls	ory	
Following Curricula	International Management and Engineering: Specialisation I. Elect		npulsory	
	Mechanical Engineering and Management: Specialisation Manager			
	Biomedical Engineering: Specialisation Artificial Organs and Reger	erative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthes Biomedical Engineering: Specialisation Medical Technology and Co		0.774	

Course L2009: Marketing of	Innovations
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
	Prof. Christian Lüthje
Language	
Cycle Content	I. Introduction
	 Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

Course L0862: PBL Marketing	g of Innovations
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1)
	forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation,
	managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will
	be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making wtihin a
	market simulation game.
Literature	

Courses					
Title		Тур	Hrs/wk	СР	
Applied Design Methodology in Mechatronics (L1523)		Lecture	2	2	
Applied Design Methodology in Me	chatronics (L1524)	Project-/problem-based Learn	ng 3	4	
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical des	sign or computer-sciences			
Knowledge					
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results			
Professional Competence					
Knowledge	Science-based working on interdisciplinary	y product design considering targeted application o	f specific product	design techniqu	
Clille					
SKIIIS	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Applicatio various product design techniques following theoretical aspects.				
	various product design techniques followin	ig theoretical aspects.			
Personal Competence					
Social Competence	e Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application				
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the design	gn and development process according to the targe	et and topic of the	e design	
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-wo	ork			
scale					
Assignment for the	International Management and Engineerin	g: Specialisation II. Product Development and Prod	uction: Elective C	ompulsory	
Following Curricula	International Management and Engineerin	g: Specialisation II. Mechatronics: Elective Compuls	sory		
	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory				
	Mechatronics: Specialisation System Design: 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 Management and Business Administration: Elective Compulsory				
	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory				
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Compulsory			

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	 Systematic analysis and planning of the design process for products combining a multitude of disciplines Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics) Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,) Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making Value-analysis Derivation of architectures and architectural management Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) Project-execution methods (Scrum, Kanbaan,) Presentation-skills Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) Evaluation of selected methods at practical examples in small teams
Literature	 Definition folgt Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, KH.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 VDI-Richtlinien: 2206; 2221ff

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

Courses			
Title		Тур	Hrs/wk CP
Bioprocess Engineering - Fundame	ntals (1.08/1)	Lecture	2 3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2 1
Bioprocess Engineering - Fundame		Practical Course	2 2
		Tractical Course	ζ ζ
Module Responsible			
Admission Requirements	None		
	none, module "organic chemistry", module "	'fundamentals for process engineering"	
Knowledge			
Educational Objectives	After taking part successfully, students have	e reached the following learning results	
Professional Competence			
Knowledge	Students are able to describe the basic cond	cepts of bioprocess engineering. They are able	to classify different types of kinetic
	enzymes and microorganisms, as well as	to differentiate different types of inhibition.	The parameters of stoichiometry
	rheology can be named and mass transpo	ort processes in bioreactors can be explained	d. The students are capable to ex
		ization technology and downstream processing	
	······································		,
Skills	After successful completion of this module, s	students should be able to	
		for growth and substrate-uptake and to calcula	
	 predict qualitatively the influence of 	energy generation, regeneration of redox ec	quivalents and growth inhibition or
	fermentation process		
	 analyze bioprocesses on basis of stoid 	chiometry and to set up / solve metabolic flux e	equations
	 distinguish between scale-up criteria 	for different bioreactors and bioprocesses (ana	erobic, aerobic as well as microaer
	to compare them as well as to apply t	them to current biotechnical problem	
	 propose solutions to complicated biot 	echnological problems and to deduce the corre	sponding models
	 to explore new knowledge resources 	and to apply the newly gained contents	
	 identify scientific problems with concr 	rete industrial use and to formulate solutions.	
	 to document and discuss their proced 	lures as well as results in a scientific manner	
	 to document and discuss their proced 	lures as well as results in a scientific manner	
	 to document and discuss their proced 	lures as well as results in a scientific manner	
Personal Competence	 to document and discuss their proced 	lures as well as results in a scientific manner	
			in small teams to enhance the abil
	After completion of this module participants	s should be able to debate technical questions	
	After completion of this module participants		
Social Competence	After completion of this module participants take position to their own opinions and incre	s should be able to debate technical questions	and scientific environments.
Social Competence	After completion of this module participants take position to their own opinions and incre After completion of this module participants	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a	and scientific environments.
Social Competence	After completion of this module participants take position to their own opinions and incre	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a	and scientific environments.
Social Competence Autonomy	After completion of this module participants take position to their own opinions and incre After completion of this module participants	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum.	and scientific environments.
Social Competence Autonomy	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum.	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum.	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points Course achievement	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points Course achievement	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments.
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments. team independently by organizing
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments. team independently by organizing
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. Lecture 84 Description I and ram, 7 semester): Specialisation Process Engine ram, 7 semester): Specialisation Bioprocess Engine	and scientific environments. team independently by organizing
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. Lecture 84 Description I and ram, 7 semester): Specialisation Process Engine ram, 7 semester): Specialisation Bioprocess Engine	and scientific environments. team independently by organizing
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr General Engineering Science (German progr Bioprocess Engineering: Core Qualification: 6	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. Lecture 84 Description I and ram, 7 semester): Specialisation Process Engine ram, 7 semester): Specialisation Bioprocess Engine	and scientific environments. team independently by organizing
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr General Engineering Science (German progr Bioprocess Engineering: Core Qualification: G General Engineering Science (English progra	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. ecture 84 Description I and ram, 7 semester): Specialisation Process Engine ram, 7 semester): Specialisation Bioprocess Engine ram, 7 semester): Specialisation Bioprocess Engine	and scientific environments. team independently by organizing environments erring: Compulsory gineering: Compulsory ineering: Compulsory
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Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr General Engineering Science (German progr Bioprocess Engineering: Core Qualification: C General Engineering Science (English progra General Engineering Science (English progra General Engineering: Specialisation Artifi Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medi	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. 	and scientific environments. team independently by organizing evering: Compulsory gineering: Compulsory ering: Compulsory ering: Compulsory ulsory ulsory
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	After completion of this module participants take position to their own opinions and incre After completion of this module participants workflow and to present their results in a pl Independent Study Time 96, Study Time in L 6 Compulsory Bonus Form Yes 5 % Subject theoretical practical work Written exam 90 min General Engineering Science (German progr General Engineering Science (German progr Bioprocess Engineering: Core Qualification: C General Engineering Science (English progra General Engineering Science (English progra General Engineering: Specialisation Artifi Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medi	s should be able to debate technical questions ease their capacity for teamwork in engineering s will be able to solve a technical problem in a enum. ecture 84 Description I and ram, 7 semester): Specialisation Process Engine ram, 7 semester): Specialisation Bioprocess Engine ram, 7 semester): Specialisation Process Engine ram, 7 semester): Speciali	and scientific environments. team independently by organizing evering: Compulsory gineering: Compulsory ering: Compulsory ering: Compulsory ulsory ulsory

Course L0841: Bioprocess Er	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	 Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) Kinetic of subtrate consumption and product formation (Prof. Zeng) Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) Transport process in a bioreactor (Prof. Zeng) Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	 K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess En	igineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

Course L0843: Bioprocess En	ngineering - Fundamental Practical Course
Тур	Practical Course
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Courses				
Title		True	Une fools	СР
Introduction to Anatomy (L0384)		Typ Lecture	Hrs/wk	3
Module Responsible	Prof IIdo Schumacher	Lociare	-	5
Admission Requirements	None			
Recommended Previous				
Knowledge	NOIC			
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence		ing rearing repairs		
	The students can describe basal structures and functions of inte The students can describe the basic macroscopy and microscop	-	nusculoskeletal system.	
Skills	The students can recognize the relationship between given ana can explain the relevance of structures and their functions in the		•	imon diseases; th
Personal Competence				
Social Competence	The students can participate in current discussions in biomedica	al research and medici	ne on a professional level	
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqu the relevant knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): S	pecialisation Biomedic	al Engineering: Compulsor	У
Following Curricula	General Engineering Science (German program, 7 semeste	er): Specialisation Me	chanical Engineering, Fo	ocus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory			
	Electrical Engineering: Specialisation Medical Technology: Elect	ive Compulsory		
	Engineering Science: Specialisation Biomedical Engineering: Co	mpulsory		
	General Engineering Science (English program, 7 semeste	r): Specialisation Me	chanical Engineering, Fo	ocus Biomechani
	Compulsory			
	General Engineering Science (English program, 7 semester): Sp			-
	General Engineering Science (English program, 7 semester): Sp		I Engineering: Compulsory	/
	Mechanical Engineering: Specialisation Biomechanics: Compuls	-		
	Biomedical Engineering: Specialisation Medical Technology and	-		
	Biomedical Engineering: Specialisation Management and Busine			
	Biomedical Engineering: Specialisation Artificial Organs and Reg			
	Biomedical Engineering: Specialisation Implants and Endoprost	leses: Elective Compu	ISOFV	

Course L0384: Introduction t	o Anatomy	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study	r Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Lange	
Language		
Cycle	SoSe	
Content	General Anatomy	V
	1 st week:	The Eucaryote Cell
	2 nd week:	The Tissues
	3 rd week:	Cell Cycle, Basics in Development
	4 th week:	Musculoskeletal System
	5 th week:	Cardiovascular System
	6 th week:	Respiratory System
	7 th week:	Genito-urinary System
	8 th week:	Immune system
	9 th week:	Digestive System I
	10 th week:	Digestive System II
	11 th week:	Endocrine System
	12 th week:	Nervous System
	13 th week:	Exam
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

Courses				
Title		Тур	Hrs/wk	СР
Introduction to Physiology (L0385)		Lecture	2	3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fol	owing learning results		
Professional Competence				
Knowledge	The students can			
	 describe the basics of the energy metabolism; 			
	 describe physiological relations in selected fields of m 	uscle, heart/circulation,	neuro- and sensory physio	logy.
Chille	The students are described by effects of basis bodily for the	(
SKIIIS	The students can describe the effects of basic bodily functio of forces and vital functions) and relate them to similar tech		n and processing of inform	hation, developme
Personal Competence		lical systems.		
	The students can conduct discussions in research and medic	ine on a technical level		
social competence	The students can find solutions to problems in the field of ph		and metrological.	
	· · · · · · · · · · · · · · · · · · ·	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
Autonomy	The students can derive answers to questions arising in th	e course and other phy	siological areas, using teo	chnical literature,
	themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 semester)	: Specialisation Biomedie	cal Engineering: Compulso	ry
Following Curricula	General Engineering Science (German program, 7 seme	ster): Specialisation M	echanical Engineering, F	ocus Biomechani
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory	activo Compulsory		
	Electrical Engineering: Specialisation Medical Technology: El Engineering Science: Specialisation Biomedical Engineering:			
	General Engineering Science (English program, 7 seme		echanical Engineering E	ocus Biomechani
	Compulsory		;,;,	
	General Engineering Science (English program, 7 semester):	Specialisation Biomedic	al Engineering: Compulsor	у
	General Engineering Science (English program, 7 semester):	Specialisation Biomedic	al Engineering: Elective Co	ompulsory
	Mechanical Engineering: Specialisation Biomechanics: Comp	ulsory		
	Biomedical Engineering: Specialisation Medical Technology a	nd Control Theory: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Management and Bus	iness Administration: El	ective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and			
	Biomedical Engineering: Specialisation Implants and Endopro		ulsory	
	Technomathematics: Specialisation III. Engineering Science:			

Course L0385: Introduction to Physiology		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Gerhard Engler	
Language	DE	
Cycle	SoSe	
Content		
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme	
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier	

ourses		Тур	Hrs/wk	СР
troduction to Radiology and Radia	tion Therapy (L0383)	Lecture	2	3
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
	After taking part successfully, students have	reached the following learning results		
Professional Competence Knowledge	Therapy			
	The students can distinguish different types	of currently used equipment with respect	to its use in radiation th	erapy.
	The students can explain treatment plans us	ed in radiation therapy in interdisciplinary	/ contexts (e.g. surgery,	nternal medicine)
	The students can describe the patients	passage from their initial admittanc	e through to follow-up	care.
	Diagnostics			
	The students can illustrate the technical ba well as sectional imaging techniques (CT, MI		cluding angiography and	d mammography,
	The students can explain the diagnostic as techniques.	well as therapeutic use of imaging techni	ques, as well as the tech	inical basis for the
	The students can choose the right treatmen	method depending on the patient's clinic	al history and needs.	
	The student can explain the influence of tec	nnical errors on the imaging techniques.		
	The student can draw the right conclusions l	based on the images' diagnostic findings o	or the error protocol.	
Skills	Therapy			
	The students can distinguish curative and pa	Iliative situations and motivate why they	came to that conclusion.	
	The students can develop adequate therapy	concepts and relate it to the radiation bio	logical aspects.	
	The students can use the therapeutic princip	le (effects vs adverse effects)		
	The students can distinguish different kind tumor) and choose the energy needed in the		depending on the situa	tion (location of
	The student can assess what an individua groups, self-help groups, social services, psy		e.g. follow-up treatment	, sports, social h
	Diagnostics			
	The students can suggest solutions for repai	rs of imaging instrumentation after having	g done error analyses.	
	The students can classify results of imagin anatomy, pathology and pathophysiology.	g techniques according to different grou	ps of diseases based or	n their knowledge
Personal Competence				
Social Competence	The students can assess the special social s The students are aware of the special, o measures and can meet them appropriately	ten fear-dominated behavior of sick pe		
Autonomy	The students can apply their new knowledge The students can introduce younger student			
	The students are able to access anatomical and acquire the relevant knowledge themse		te competently in conve	rsations on the to
Workload in Hours	Independent Study Time 62, Study Time in I	ecture 28		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale	General Engineering Science (German progr	am 7 competer): Enocialization Piomodic	al Engineering: Compulse	
-	General Engineering Science (German progr		· · ·	-
	Compulsory	,		
	Data Science: Specialisation Medicine: Comp	oulsory		
	Electrical Engineering: Specialisation Medica	I Technology: Elective Compulsory		
	Engineering Science: Specialisation Biomedi			
	General Engineering Science (English pro			

Module Manual M.Sc. "Biomedical Engineering"

General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introduction t	to Radiology and Radiation Therapy	
Тур	Lecture	
Hrs/wk	2	
СР		
	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	of. Ulrich Carl, Prof. Thomas Vestring	
Cycle		
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments	
Literature	 "Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999 	
	 "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr – 	
	4. Auflage - Verlag Urban & Fischer – erschienen 02.03.2006	
	ISBN: 978-3-437-23960-1	
	• "Strahlentherapie und Onkologie für MTA-R" von R. Sauer –	
	5. Auflage 2003 - Verlag Urban & Schwarzenberg – erschienen 08.12.2009	
	ISBN: 978-3-437-47501-6	
	"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus-	
	8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012	
	ISBN: 978-3-13-567708-8	
	• "Der Körper des Menschen " von A. Faller u. M. Schünke -	
	16. Auflage 2004 – Georg Thieme Verlag – erschienen 18.07.2012	
	ISBN: 978-3-13-329716-5	
	 "Praxismanual Strahlentherapie" von Stöver / Feyer – 	
	1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000	

Courses		
Title	Typ Hrs/wk CP	
Experimental Methods in Biomecha	anics (L0377) Lecture 2 3	
Module Responsible	Prof. Michael Morlock	
Admission Requirements	None	
	It is recommended to participate in "Implantate und Frakturheilung" before attending "Experimentelle Methoden".	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.	
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.	
	The students can describe different measurement techniques for forces and movements, and choose the adequate techni	que for
	given task.	
Cl://-		
SKIIIS	The students can describe the basic handling of several experimental techniques used in biomechanics.	
Personal Competence		
Social Competence	The students can, in groups, solve basic experimental tasks.	
Autonomy	The students can, in groups, solve basic experimental tasks.	
Autonomy	The students can, in groups, solve basic experimental tasks.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	3	
Course achievement	None	
Examination	Written exam	
Examination duration and	90 min	
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biom	echanio
Following Curricula	Compulsory	
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biom	echanio
	Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory	
	Mechanical Engineering Science (English program, 7 seriester): Specialisation Biomedical Engineering: 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 Management and Business Administration: Elective Compulsory	
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory	

Course L0377: Experimental	Methods in Biomechanics			
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	ent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Michael Morlock			
Language	DE			
Cycle	SoSe			
Content				
Literature	Wird in der Veranstaltung bekannt gegeben			

Courses							
Title		T	Une fools	СР			
Artificial Joint Replacement (L1306)		Typ Lecture	Hrs/wk	3			
Module Responsible	Prof. Michael Morlock						
Admission Requirements	None						
	Basic knowledge of orthopedic and surgic	al techniques is recommended.					
Knowledge	5						
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results					
Professional Competence							
Knowledge	The students can name the different kinds	s of artificial limbs.					
Cl://l-		The students can explain the advantages and disadvantages of different kinds of endoprotheses.					
SKIIIS	The students can explain the advantages	and disadvantages of different kinds of end	loprotneses.				
Personal Competence							
Social Competence	The students are able to discuss issues re	lated to endoprothese with student mates a	and the teachers.				
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.						
Autonomy		on on their own. They can also judge the in	normation with respect to	res creationity.			
Workload in Hours	Independent Study Time 62, Study Time i	n Lecture 28					
Credit points	3						
Course achievement	None						
Examination	Written exam						
Examination duration and	90 min						
scale							
Assignment for the	International Management and Engineerir	g: Specialisation II. Process Engineering an	d Biotechnology: Elective	Compulsory			
Following Curricula	Materials Science: Specialisation Nano an						
	Biomedical Engineering: Specialisation Ar	ificial Organs and Regenerative Medicine:	Elective Compulsory				
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Compulsory					
	Biomedical Engineering: Specialisation Me	dical Technology and Control Theory: Elect	ive Compulsory				
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration: El	ective Compulsory				
	Orientierungsstudium: Core Qualification:	Elective Compulsory					
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Com	pulsory				
	Theoretical Mechanical Engineering: Spec	ialisation Bio- and Medical Technology: Flee	tive Compulsory				

Course L1306: Artificial Joint	Replacement					
Тур	Lecture					
Hrs/wk	2					
СР	3					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28					
Lecturer	Prof. Michael Morlock					
Language	DE					
Cycle						
Content	Inhalt (deutsch)					
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)					
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)					
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)					
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)					
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)					
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)					
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)					
	IE HAND (Anatomie, Biomechanik, Ge-lenkersatz)					
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)					
Literature	Literatur:					
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.					
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994					
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.					
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.					
	Sobotta und Netter für Anatomie der Gelenke					

Courses					
Title		Тур	Hrs/wk	СР	
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3	
Module Responsible	Johannes Kreuzer				
Admission Requirements	None				
Recommended Previous	Basics in Control, Basics in Physiology				
Knowledge					
Educational Objectives	After taking part successfully, students h	nave reached the following learning results			
Professional Competence					
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals i human physiology will be similarly introduced like knowledge in control theory.				
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system f example in for anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural net illustrated. The operation of simple equivalent circuits will be discussed.				
Skills	Application of modeling, identification, c	ontrol technology in the field of medical techr	nology.		
Personal Competence					
Social Competence	Students can develop solutions to specif	ic problems in small groups and present their	results		
Autonomv	Students are able to find necessary liter	rature and to set it into the context of the lea	cture. They are able to c	ontinuously evalua	
	their knowledge and to take control of their learning process. They can combine knowledge from different courses to form				
	consistent whole.				
Werkland in Hours	Independent Study Time 62, Study Time	in Lastura 29			
Credit points		III Lecture 26			
Course achievement					
Examination					
Examination duration and					
scale					
Assignment for the	Electrical Engineering: Specialisation Me	dical Technology: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory		
	Biomedical Engineering: Specialisation Ir	mplants and Endoprostheses: Elective Compu	Ilsory		
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: E	ective Compulsory		
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Comp	oulsory		

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

Courses					
Title		ту		Hrs/wk	СР
Medical Technology Lab (L1096)		Pri	oject-/problem-based Learning	6	6
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous	sound programming skills	Java / C++)			
Knowledge	skills in R/Matlab				
	knowledge of image proces	sing			
	principles of math (algebra	, analysis/calculus)			
	principles of stochastics				
Educational Objectives	After taking part successfu	ly, students have reached the following	learning results		
Professional Competence		·			
Knowledge	The students recognize the	complexity of medical technology and	can explain, which methods a	re appropriate	e to solve a proble
	at hand.				
Skills	The students are able to ar	alyze and solve problems in medical tec	hnology.		
Personal Competence					
Social Competence		roject aims and scope and organize th	e project as team work. The	y can present	t their results in a
	appropriate manner.				
Autonomy	The students take respons	bility for their tasks and coordinate their	r individual work with other gr	oup members	5. They deliver the
,		ndently acquire additional knowledge by	-	-	2
Workload in Hours	Independent Study Time 9	5, Study Time in Lecture 84			
Credit points	6 Compulsory Bonus Form	Description			
Course achievement		up discussion			
Examination	Written elaboration				
		e: over the course of the semester			
scale	approx. o pages, ame fall	e. etc. the course of the semester			
	Electrical Engineering: Spe	cialisation Medical Technology: Elective (Compulsory		
Following Curricula	• • •	ecialisation Medical Technology and Con		orv	
		ecialisation Medical Technology and Con			

Course L1096: Medical Techr	nology Lab
Тур	Project-/problem-based Learning
Hrs/wk	6
СР	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Alexander Schlaefer
Language	DE/EN
Cycle	SoSe
Content	The actual project topic will be defined as part of the project.
Literature	Wird in der Veranstaltung bekannt gegeben.

Courses					
Title		Тур	Hrs/wk	СР	
Advanced Topics in Control (L0661)		Lecture	2	3	
Advanced Topics in Control (L0662)		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear	matrix inequalities			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the	following learning results			
Professional Competence					
Knowledge	 Students can explain the advantages and shortcom They can explain the representation of nonlinear sy They can explain how stability and performance co They can explain how gridding techniques can be u They are familiar with polytopic and LFT representation associated with each of these model structures Students can explain how graph theoretic concersystems 	ystems in the form of quasi-LPV sy onditions for LPV systems can be fo used to solve analysis and synthes entations of LPV systems and so	stems ormulated as LMI cc is problems for LPV ome of the basic s	systems synthesis techniqu	
	 They can explain the convergence properties of fin They can explain analysis and synthesis conditions 		ing either LTI or LP\	/ agent models	
	 Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers 				
Skills	 Students are capable of constructing LPV model scheduled controllers; they can do this using polyto. They are able to use standard software tools (Matla Students are able to design distributed formation Matlab tools provided 	opic, LFT or general LPV models ab robust control toolbox) for these	e tasks		
	 Students are able to design distributed controllers Students can work in small groups and arrive at joint resu Students are able to find required information in sources solve given problems. 	ılts.	-		
Workload in Hours Credit points	Independent Study Time 124, Study Time in Lecture 56				
Course achievement					
Examination					
Examination duration and					
scale					
	Electrical Engineering: Specialisation Control and Power S	Systems Engineering: Elective Com	pulsory		
-	Aircraft Systems Engineering: Specialisation Avionic Syste				
	Aircraft Systems Engineering: Specialisation Aircraft System Aircraft Systems Engineering: Core Qualification: Elective International Management and Engineering: Specialisatio Mechatronics: Specialisation System Design: Elective Con Mechatronics: Specialisation Intelligent Systems and Robe Biomedical Engineering: Specialisation Implants and Endo	ems: Elective Compulsory Compulsory n II. Mechatronics: Elective Compu npulsory otics: Elective Compulsory	lsory		
	Biomedical Engineering: Specialisation Medical Technolog Biomedical Engineering: Specialisation Management and	gy and Control Theory: Elective Co			

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

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

Courses					
Title			Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and	Applications (L0371)		Lecture	3	5
Bioelectromagnetics: Principles and	Applications (L0373)		Recitation Section (small) 2	1
Module Responsible	Prof. Christian Schuste	er			
Admission Requirements	None				
Recommended Previous Knowledge	Basic principles of phy	ysics			
Educational Objectives	After taking part succe	essfully, students have reacl	ned the following learning results		
Professional Competence					
Knowledge	of electromagnetic fie them corresponding t techniques for charac	elds in biological tissue. The to wavelength and frequence	ships, and methods of bioelectron y can define and exemplify the n cy of the fields. They can give a ic fields in practical applications nedical technology.	most important physical print overview over measur	phenomena and ord ement and numeric
Skills	do this they can relat important effects that frequency, respectivel	te to and make use of the t these models predict for ly, and they can analyze the	haracterize the behavior of electr elementary solutions of Maxwell' biological tissue, they can order em in a quantitative way. They ar of electromagnetic fields for thera	s Equations. They are ab the effects correspondir e able to develop validati	le to assess the mo ng to wavelength a on strategies for the
Personal Competence Social Competence	Students are able to v English (e.g. during sn	• •	lated tasks in small groups. They	v are able to present thei	ir results effectively
Autonomy	context of the lecture other lectures (e.g. th	. They are able to make a d	n subject related, professional p connection between their knowled elds, fundamentals of electrical e netics in English.	dge obtained in this lectu	re with the content
Workload in Hours	Independent Study Tir	me 110, Study Time in Lectu	re 70		
	6				
Course achievement	Compulsory Bonus Yes None	Form Presentation	Description		
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the Following Curricula	Electrical Engineering: International Managen Biomedical Engineerin Biomedical Engineerin	Specialisation Medical Tech ment and Engineering: Speci ng: Specialisation Artificial O ng: Specialisation Manageme	ngineering, Optics, and Electroma nology: Elective Compulsory alisation II. Electrical Engineering rgans and Regenerative Medicine: ent and Business Administration: E chnology and Control Theory: Elec	Elective Compulsory Elective Compulsory	tive Compulsory
	-	ig: Specialisation Implants a			

Тур	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Course L0373: Bioelectromag	ourse L0373: Bioelectromagnetics: Principles and Applications		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Christian Schuster		
Language	DE/EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

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

Module Manual M.Sc. "Biomedical Engineering"

Mechatronics: Thesis: Compulsory
Biomedical Engineering: Thesis: Compulsory
Microelectronics and Microsystems: Thesis: Compulsory
Product Development, Materials and Production: Thesis: Compulsory
Renewable Energies: Thesis: Compulsory
Naval Architecture and Ocean Engineering: Thesis: Compulsory
Ship and Offshore Technology: Thesis: Compulsory
Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory
Theoretical Mechanical Engineering: Thesis: Compulsory
Process Engineering: Thesis: Compulsory
Water and Environmental Engineering: Thesis: Compulsory
 Certification in Engineering & Advisory in Aviation: Thesis: Compulsory