

Module Manual

Master of Science

Biomedical Engineering

Cohort: Winter Term 2017

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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: Business	& Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	 Students are able to find their way around selected special areas of management within the scope of business management. Students are able to explain basic theories, categories, and models in selected special areas of business management. Students are able to interrelate technical and management knowledge.
Personal Competence Social Competence Autonomy	
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	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	The Nontechnical Academic Programms (NTA)
Kilowieuge	imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance management, collaboration and professional and personnel management competences. The department implements these training object its teaching architecture, in its teaching and learning arrangements, in teaching areas and by means of teaching offerings in which si can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are po
	two different catalogues for nontechnical complementary courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical act programms follow the specific profiling of TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regards the individual development of competences provides orientation knowledge in the form of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semes view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters the course of studies.
	Teaching and Leaving Avenues and
	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 dealin interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in courses.
	Fields of Teaching
	are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication s migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.
	The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-c communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.
	The Competence Level
	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differen reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scient theoretical level of abstraction in the B.Sc.
	This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership func Bachelor's and Master's graduates in their future working life.
	Specialized Competence (Knowledge)
	Students can
	 explain specialized areas in context of the relevant non-technical disciplines, outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning different specialist disciplines relate to their own discipline and differentiate it as well as make connections, sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation specialized sciences are subject to individual and socio-cultural interpretation and historicity, Can communicate in a foreign language in a manner appropriate to the subject.
Skills	Professional Competence (Skills)
	In selected sub-areas students can
	 apply basic and specific methods of the said scientific disciplines, aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, to handle simple and advanced questions in aforementioned scientific disciplines in a successful manner, justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relation the subject.



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.



Courses				
Title		Тур	Hrs/wk	CP
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Problem-based Learning	2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence				
Knowledge	Students can explain the statistical methods and the	e conditions of their use.		
Skills	Students are able to use the statistics program to so	Ive statistics problems and to interpret and depict th	ne results	
Personal Competence				
•	Team Work, joined presentation of results			
,, ,				
Autonomy	To understand and interpret the question and solve			
Workload in Hours	Independent Study Time 110, Study Time in Lecture	> 70		
Credit points				
	Written exam			
Examination duration and scale				
	Mechanical Engineering and Management: Special	isation Management: Elective Compulson		
Curricula	Mechatronics: Specialisation System Design: Electi	• • • •		
Curreula	Mechatronics: Specialisation System Design: Lieu			
	Biomedical Engineering: Core qualification: Compu			
	Product Development, Materials and Production: Computer	•		
	Theoretical Mechanical Engineering: Specialisation		24	
	Theoretical Mechanical Engineering: Specialisation		у	

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



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

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



Courses				
litle		Тур	Hrs/wk	CP
Vedical 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 have re	ached the following learning results		
Professional Competence				
Knowledge				
	Students can:			
	 Describe the system configuration and 	components of the main clinical imaging system	<u>.</u>	
		nd the overall system of the imaging systems fun		
		es that make imaging possible and use with the		ons:
	 Name and describe the physical effects 			,
		ution can be influenced and how to characterize	the images generated;	
	 Explain which image reconstruction me 		0 0 /	
	Describe and explain the main clinical uses of	the different systems.		
Skills	Students are able to:			
	 Explain the physical processes of image 	es and assign to the systems the basic mathema	tical or physical equations re	quired;
		iging systems using the mathematical or physica		
		rent system components on the spatial and temp		stems;
		ent imaging systems for a number of clinical appl		
	Select a suitable imaging system for an application	ation.		
Personal Competence				
Social Competence	none			
Autonomy	Students can:			
	Understand which physical effects are			
	Decide independently for which clinica	l issue a measuring system can be used.		
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory		
Curricula	Biomedical Engineering: Core qualification: Co			
		on: Specialisation Product Development: Elective	Compulsory	
		n: Specialisation Production: Elective Compulso		
		n: Specialisation Materials: Elective Compulsory		
		I Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialis		mpulsorv	

Course L0819: Medical Imaging Systems		
Тур	Lecture	
Hrs/wk	4	
CP	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Dr. Michael Grass, Dr. Tim Nielsen, Dr. Sven Prevrhal, 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.	

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Module M1179: Medical Ba	asics and Pathology			
Courses				
Title		Тур	Hrs/wk	CP
Medical Basics and Pathology I (L1599)		Lecture	2	2
Medical Basics and Pathology II (L1600)		Lecture	2	2
Medical Basics and Pathology III (L1602)	Lecture	2	2
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have r	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	ecture 84		
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 minutes			
Assignment for the Following	Biomedical Engineering: Core qualification: 0	Compulsory		
Curricula				

Course L1599: Medical Basics and	d Pathology I
Тур	Lecture
Hrs/wk	2
CP	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, mini-laparoscopy and our ICU as well as out patient clinics.
Literature	Wird in der Veranstaltung bekannt gegeben



_	
	Lecture
Hrs/wk	
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
	Il 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
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1602: Medical Basics and	d 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
	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.



MODULE M1164: Practical (Course Product Development, Ma	terials and Production		
Courses				
litle		Тур	Hrs/wk	СР
Practical Course Product Development,	Materials and Production (L1566)	Laboratory	6	6
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge	Lectures: Structure and Properties of F Production: Lecture: Production Engineering	nent I incl. CAD practical training Metallic Materials for Aircraft Applications, Introduc Polymers, Structure and Properties of Composites, N	-	and Composites
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence		~ ~		
Skills	 represent more complex context of diff describe functionality of modern meas Students are capable of 	erent fields of study. urement instrumentations and machine technologie	əs.	
	 applying theoretical knowledge for pra applying provided experimental methor analyzing and evaluating experimenta applying modern measurement instrurt 	ods for examining contexts of different fields of study al results by using provided methods.	Ι.	
Personal Competence				
Social Competence	• carry out and document experimental	work in groups. ults in mixed teams of different fields of study.		
Autonomy	Students are able to carry out parts of experimental work in choose and apply suitable instruments assess own strengths and weaknesse	S.		
Workload in Hours	Independent Study Time 96, Study Time in Le	cture 84		
Credit points	6			
Examination	Written elaboration			
Examination duration and scale				
Assignment for the Following	Biomedical Engineering: Core qualification: C	Compulsory		
Curricula	Product Development, Materials and Producti	on: Core qualification: Compulsory		



	Product Development, Materials and Production
Тур	Laboratory
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Wolfgang Hintze, Prof. Josef Schlattmann, Prof. Dieter Krause, Prof. Claus Emmelmann, Prof. Uwe Weltin, Prof. Bodo Fiedler, Prof. Hermann
	Lödding, Prof. Michael Morlock, Prof. Gerold Schneider, Prof. Thorsten Schüppstuhl, Prof. Otto von Estorff, Prof. Jörg Weißmüller
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				
ïtle		Тур	Hrs/wk	CP
asestudies Surgery and Internal Medi	cine (L1603)	Seminar	5	5
linical Internship (L1587)		Laboratory Course	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	The lectures addressing medical issues from the	concentration Biomedical Engineering in the respe	ctive BSc Programs.	
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
	owledge The students learn the process of clinical practice regarding medical history, diagnosis and treatment decision with representative s			
Knowledge	The students learn the process of clinical practic	ce regarding medical history, diagnosis and treatm	nent decision with repr	esentative surgical
Knowledge		ce regarding medical history, diagnosis and treatn d get an insight into the daily patient care through c		
		d get an insight into the daily patient care through c		
	medical diseases in the various departments, and	d get an insight into the daily patient care through c		
	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients.	d get an insight into the daily patient care through c		
Skills Personal Competence	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients.	d get an insight into the daily patient care through c		
Skills Personal Competence Social Competence	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients.	d get an insight into the daily patient care through c		
Skills Personal Competence Social Competence Autonomy	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients.	d get an insight into the daily patient care through c		•
Skills Personal Competence Social Competence Autonomy Workload in Hours	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients.	d get an insight into the daily patient care through c		•
Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients. Independent Study Time 96, Study Time in Lectur 6	d get an insight into the daily patient care through c		•
Skills Personal Competence Social Competence Autonomy Workload in Hours	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients. Independent Study Time 96, Study Time in Lectur 6	d get an insight into the daily patient care through c		•
Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients. Independent Study Time 96, Study Time in Lectur 6 Written elaboration	d get an insight into the daily patient care through c		•
Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points Examination Examination duration and scale	medical diseases in the various departments, and Interpreting and explaining the medical history and Dealing with patients. Dealing with patients. Dealing with patients. Independent Study Time 96, Study Time in Lectur 6 Written elaboration 5 Pages (10 Case studies) Biomedical Engineering: Core qualification: Corr	d get an insight into the daily patient care through c nd medical records of a patient.		•

Course L1603: Casestudies Surge	
Тур	Seminar
Hrs/wk	5
CP	5
Workload in Hours	Independent Study Time 80, Study Time in Lecture 70
Lecturer	Dr. Dominic Wichmann, Dr. Johannes Kluwe
Language	DE
Cycle	WiSe/SoSe
	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 Internship	
Тур	Laboratory Course
Hrs/wk	1
CP	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



Module M1214: Project wo	ork		
Courses			
Title	Typ Hrs/wk CP		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	Subjects of the Master program and the specialisations.		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	 Students can explain the project as well as their autonomously gained knowledge and relate it to current issues of their field of study They can explain the basic scientific methods they have worked with. 	r <u>.</u>	
Skills	The students are able to autonomously solve a limited scientific task under the guidance of an experienced researcher. They can justify and explain their approach for problem solving; they can draw conclusions from their results, and then can find new ways and methods for their work Students are capable of comparing and assessing alternative approaches with their own with regard to given criteria.		
Personal Competence			
Social Competence	The students are able to condense the relevance and the structure of the project work, the work procedure and the sub-problems presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their per supervisors.		
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.		
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0		
Credit points	12		
Examination	Project (accord. to Subject Specific Regulations)		
Examination duration and scale	presentation 20 minutes		
Assignment for the Following Curricula			

Specialization Implants and Endoprostheses

TUHH

Module M0623: Intelligent	Systems in Medicine			
Courses				
Title		Тур	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)		Lecture	2	3
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2
Intelligent Systems in Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, Java/C++ and R/Matlab advanced programming skills 			
Educational Objectives	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge	The students are able to analyze and solve clinical treatment planning. They are able to explain methods for classification can compare different methods for representing medical challenges due to the clinical nature of the data and its acquire	n and their respective advantages and disa knowledge. They can evaluate methods i	dvantages in clinica n the context of cli	I contexts. The students
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.			
Personal Competence				
Social Competence	The students discuss the results of other groups, provide he	Ipful feedback and can incoorporate feedba	ack into their work.	
Autonomy	The students can reflect their knowledge and document the	results of their work. They can present the r	esults in an appropi	iate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			-
Examination	Written exam			-
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering	: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical Technology:	Elective Compulsory		
	Computational Science and Engineering: Specialisation Sy	stems Engineering and Robotics: Elective C	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Robot	ics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	d Regenerative Medicine: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and E	Business Administration: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Specialisation Bio- an	d Medical Technology: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Technical Complement	ntary Course: Elective Compulsory		

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



ourse L0334: Intelligent Systems in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	
	·	
Course L0333: Intelligent Systems	s in Medicine	
Тур	Recitation Section (small)	
Hrs/wk	1	

1113/WK	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Courses				
Title		Тур	Hrs/wk	CP
ntelligent Autonomous Agents and Cogr	itive Robotics (L0341)	Lecture	2	4
ntelligent Autonomous Agents and Cogr	itive 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 rea	ched the following learning results		
Professional Competence				
Skills	decision problems and algorithms for solving the Bayesian networks can be employed as a know can define decision making procedures in simple context, students can describe techniques for measuring the value of information. Students techniques for achieving desired states. Studed different types of equilibria, social choice function Students can select an appropriate agent arch derive decision trees and apply basic optimizat networks and apply bayesian reasoning for sim scenarios. For simple and complex decision ma	atures of environments. The notion of adversarial ag nese problems. For dealing with uncertainty in real- vledge representation and reasoning formalism in sta- ole and sequential settings, with and with complete r solving (partially observable) Markov decision p can identify techniques for simultaneous localizat ents can explain coordination problems and decisi- ons, voting protocol, and mechanism design technique nitecture for concrete agent application scenarios. tion techniques. For those applications they can also apple queries. Students can also name and apply diffi- king students can compute the best action or policie: erent equilibria states,e.g., Nash equilibria. For mu- tain the results.	world scenarios, stude atic and dynamic setti access to the state o roblems, and they c ion and mapping, ar on making in a multi es. For simplified agent o create Bayesian net erent sampling technis of concorete settings	ents can summarize h ngs. In addition, stude f the environment. In t an recall techniques nd can explain plann -agent setting in term application students of works/dynamic Bayes ques for simplified ag . In multi-agent situatio
Personal Competence	Studente are able to discuse their colutions to p	rablama with others. They communicate in English		
oociai oonipelence		roblems with others. They communicate in English		
Autonomy	Students are able of checking their understandi	ng of complex concepts by solving varaints of concre	te problems	
Workload in Hours	Independent Study Time 124, Study Time in Lea	cture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence	Engineering: Elective Compulsory		
Curricula	Computational Science and Engineering: Speci	alisation Systems Engineering and Robotics: Electiv	e Compulsory	
	0	sation Production Technology: Elective Compulsory		
		ecialisation II. Information Technology: Elective Com	pulsory	
	Mechatronics: Technical Complementary Cours	e: Elective Compulsory		
	• • •	I Organs and Regenerative Medicine: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Implant	• • •		



Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Literature	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes r full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bay conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmat reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transi model, sensor model, inferences problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov mod 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, Direct mechaniss incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participa constraints, indivi
Literature	

Course L0512: Intelligent Autonomous Agents and Cognitive Robotics	
Тур	Recitation Section (small)
Hrs/wk	2
CP	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 M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of	f Implants (L1588)	Lecture	2	3
Experimental Methods for the Character	zation of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 t	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 Following	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
Curricula	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective Compulsory		
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Compulso	ry	
			-	

Course L1663: Nature's Hierarchie	Course L1663: Nature's Hierarchical 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	



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 scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful t engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides and their properties - 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
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE/EN	
Cycle	SoSe	
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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. 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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
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 scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



Course L0001: Fluid Mechanics 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	
	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. Durat E: Strämungemechanik: Einführung in die Theorie der Strämungen von Eluiden. Springer Verlag, Barlin, Heidelberg, 2000. 	
	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 Strömungen. Springer Verlag Berlin, Heidelberg, New York, 2006. 	
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag 	
	GmbH, Wiesbaden, 2008.	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW	
	Fachverlage GmbH, Wiesbaden, 2009.	
	 Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. Truckenbrack, F.; Elvidescharik, B. Grundlagen, und elementare. Strömungenergönge diebtebestöndigen Elvide. Springen Verlag, Barlin 	
	 Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berli 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 L0379: Ceramics Technol	ogy	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Dr. Rolf Janßen	
Language	DE/EN	
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	



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

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
-	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval o		Lecture	2	3
Experimental Methods for the Character		Lecture	2	3
Numerical Methods in Biomechanics (L1	,	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Artificial Orga	ans and Regenerative Medicine: Elective Compul	sory	
Curricula	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tech	analogy and Control Theony: Elective Compulsion		
	biomedical Engineering. Specialisation Medical Teci	mology and Control meory. Elective Compulsory		

Course L1663: Nature's Hierarchical 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	



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 scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful t engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides and their properties - 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
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE/EN	
Cycle	SoSe	
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	s in Biomechanics	
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	90 Minuten	
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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
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 scale	90 Minuten		
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 		
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008		



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Тур			
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		
	Introduction into Computational Fluid Dynamics		
Literature	 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 Strömungen. Springer Verla Berlin, Heidelberg, New York, 2006. 		
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag GmbH, Wiesbaden, 2008. 		
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007		
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW		
	Fachverlage GmbH, Wiesbaden, 2009.		
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.		
	 Schade, H., Kurz, E.: Stoffungsteine. Verlag de Grögen, beinn, New York, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlinger Verlag, B		
	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 L0379: Ceramics Technology				
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Klausur			
Examination duration and scale	90 Minuten			
Lecturer	Dr. Rolf Janßen			
Language	DE/EN			
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 a new developments in powderless forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed i 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			



Module M1334: BIO II: Biomaterials					
Courses					
Title		Тур	Hrs/wk	CP	
Biomaterials (L0593)		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	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory			ry	
Curricula	Materials Science: Specialisation Nano and Hybrid Mater	ials: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs a	and Regenerative Medicine: Elective C	ompulsory		
	Biomedical Engineering: Specialisation Implants and Eng	loprostheses: Compulsory			
	Biomedical Engineering: Specialisation Medical Technology				
	Biomedical Engineering: Specialisation Management and		mpulsory		
	Theoretical Mechanical Engineering: Technical Complement				
	Theoretical Mechanical Engineering: Specialisation Bio-	and Medical Technology: Elective Con	npulsory		



Course L0593: Biomaterials				
Тур				
Hrs/wk				
Workload in Hours	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 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 M0746: Microsyst	em Engineering			
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Courses				
Title		Тур	Hrs/wk	CP
Microsystem Engineering (L0680)		Lecture	2	4
Vicrosystem Engineering (L0682)	Problem-based Learning 1 1			
Vicrosystem Engineering (L0681)		Recitation Section (small)	1	1
Module Responsible	Prof. Manfred Kasper			
Admission Requirements	None			
Recommended Previous	Basic courses in physics, mathematics and electric engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.			
Skills	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.			
Personal Competence				
Social Competence				
,				
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 Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the Following	Electrical Engineering: Core qualification: Compulso	ry		
Curricula	Computational Science and Engineering: Specialisa	tion Systems Engineering and Robotics: Elective	Compulsory	
	International Management and Engineering: Specia	isation II. Electrical Engineering: Elective Compute	sory	
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory			
	Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Org	ans and Regenerative Medicine: Elective Comput	lsory	
	Biomedical Engineering: Specialisation Implants and	d Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	hnology and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Managemer	nt and Business Administration: Elective Compulso	ory	
	Microelectronics and Microsystems: Core qualification	on: Elective Compulsory		



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

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

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



Module M0751: Vibration	Theory			
Courses				
Title		Тур	Hrs/wk	CP
Vibration Theory (L0701)		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	ng learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration The	eory 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 Vib	ration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory			
Curricula	Computational Science and Engineering: Specialisation Scienti	fic Computing: Elective Compu	Isory	
	International Management and Engineering: Specialisation II. M	echatronics: Elective Compulse	ory	
	Biomedical Engineering: Specialisation Artificial Organs and Re	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopros			
	Biomedical Engineering: Specialisation Medical Technology an			
	Biomedical Engineering: Specialisation Management and Busin		ompulsory	
	Product Development, Materials and Production: Core qualification			
	Naval Architecture and Ocean Engineering: Core qualification: I			
	Theoretical Mechanical Engineering: Core qualification: Elective			
	Theoretical Mechanical Engineering: Technical Complementary	Course: Elective Compulsory		

Course L0701: Vibration Theory	
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	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	CP
Microsystems Technology (L0724) Microsystems Technology (L0725)		Lecture Problem-based Learning	2	4
	Prof. Hoc Khiem Trieu	Troblem-based Learning	L	2
Module Responsible	None			
Admission Requirements		0.00		
Recommended Previous Knowledge	Basics in physics, chemistry, mechanics and semiconductor technology			
Educational Objectives	After taking part successfully, students have reached the following le	arning results		
Professional Competence	Alter taking part successiony, statems have reached the following re	anning results		
Knowledge	Students are able			
Nilowicage				
	to present and to explain current fabrication techniques for mi	crostructures and especially meth	nods for the fabrication	on of microsensors a
	microactuators, as well as the integration thereof in more complex sy	vstems		
	 to explain in details operation principles of microsensors and microsensors 	croactuators and		
	 to discuss the potential and limitation of microsystems in application 	ion.		
Skills	Students are capable			
	• to analyze the feasibility of microsystems,			
	 to develop process flows for the fabrication of microstructures an 	a		
	to apply them.			
Personal Competence				
Social Competence				
	Of users are able to preverse and perform their lab arregiments in to	om work oo woll oo to procent ond	l diaquaq tha requite in	front of oudion on
	Students are able to prepare and perform their lab experiments in te	an work as well as to present and	I discuss the results in	i ironi oi audience.
Autonomy	Nero			
Autonomy	None			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics and Microsys	stems Technology: Elective Comp	ulsory	
Curricula		Compulsory		
	Computational Science and Engineering: Specialisation Systems En	ngineering and Robotics: Elective	Compulsory	
	International Management and Engineering: Specialisation II. Mech	atronics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regen	erative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthes	es: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Co	ontrol Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management and Business		ory	
	Microelectronics and Microsystems: Core gualification: Elective Con	npulsory		



Course L0724: Microsystems Tec	nnology
Тур	Lecture
Hrs/wk	2
CP	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; bacd sputtering, plasma etching, alle, Bosch process, crop process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origam microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; campetometer) Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magnetor 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
	 Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysic FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip ch bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; mice 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 Technology	
Тур	Problem-based Learning
Hrs/wk	2
CP	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				
litle		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of			give an overview of
hitewicage	theoretical and methodical basis of the method.	g are derivation of the limite element mean		give an eventiew of t
Skills	The students are capable to handle engineering problem	ns by formulating suitable finite elements, as	sembling the corresp	onding system matric
	and solving the resulting system of equations.			
D				
Personal Competence				
Social Competence				
Autonomy	The students are able to independently solve challengi	ng computational problems and develop o	wn finite element ro	utines. Problems can
	identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following	Civil Engineering: Core qualification: Compulsory			
Curricula	Energy Systems: Core qualification: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Aircraft Syst	ems: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation Air Transport	rtation Systems: Elective Compulsory		
	Computational Science and Engineering: Specialisation	Scientific Computing: Elective Compulsory		
	International Management and Engineering: Specialisation	on II. Mechatronics: Elective Compulsory		
	International Management and Engineering: Specialisation	on II. Product Development and Production:	Elective Compulsory	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants and Eng	doprostheses: Compulsory		
	Biomedical Engineering: Specialisation Management and	d Business Administration: Elective Compute	sory	
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compulso	ry	
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Comp	ulsory	
	Product Development, Materials and Production: Core qu	alification: Compulsory		
	Technomathematics: Specialisation III. Engineering Scien	nce: Elective Compulsory		
	Technomathematics: Core qualification: Elective Comput	sory		
	Theoretical Mechanical Engineering: Core qualification:	Compulsory		



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

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



Courses				
itle		Тур	Hrs/wk	CP
echnology Management (L0849)	-0)	Problem-based Learning		3
echnology Management Seminar (L085		Problem-based Learning	2	3
	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous	Bachelor knowledge in business management			
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students will gain deep insights into:			
	Technology Timing Strategies			
	 Technology Strategies and Lifecy 	cle Management (I/II)		
	 Technology Intelligence and Plan 			
	Technology Portfolio Management	ů –		
	 Technology Portfolio Methodology 	Ý		
	 Technology Acquisition and Explo 			
	 IP Management 			
	Organizing Technology Development			
	 Technology Organization & Mana 	gement		
	 Technology Funding & Controlling 			
Skills	The course aims to:			
Personal Competence Social Competence	 process-related aspects) Foster a strategic orientation to problem- corporate strategy Clarify activities of Technology Managem Strengthen essential communication sk Technology-, Innovation- and R&D-managem 	of important elements of Technology Manages solving within the innovation process as well a tent (e.g. technology sourcing, maintenance an ills and a basic understanding of manageria gement. Further topics to be discussed include nt to the management of technology, R&D and and results)	as Technology Manageme Id exploitation) al, organizational and fina a:	nt and its importance
	 Raise awareness for globabl issues 			
Autonomy	 Gain access to knowledge sources 			
	Interpret complicated cases			
	Develop presentation skills			
		70		
	Independent Study Time 110, Study Time in Lect	ture 70		
	Written exam			
	90 minutes			
	Global Innovation Management: Core qualification			
Assignment for the Following			Compulsory	
Assignment for the Following	International Management and Engineering: Spe	-		
Assignment for the Following	Mechanical Engineering and Management: Spec	cialisation Management: Elective Compulsory		
Assignment for the Following	Mechanical Engineering and Management: Spec Biomedical Engineering: Specialisation Artificial	cialisation Management: Elective Compulsory Organs and Regenerative Medicine: Elective C		
Assignment for the Following	Mechanical Engineering and Management: Spec	cialisation Management: Elective Compulsory Organs and Regenerative Medicine: Elective C and Endoprostheses: Elective Compulsory	Compulsory	



Course L0849: Technology Management		
Тур	Problem-based Learning	
Hrs/wk	3	
CP	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 Management Seminar		
Тур	Problem-based Learning	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Cornelius Herstatt	
Language	EN	
Cycle	WiSe	
Content	Aspects of and Cases in combination with the content of the lecture.	
Literature	see lecture Technology Management.	



Module M0846: Control Sy	ystems Theory and Design				
Courses					
Title		Тур	Hrs/wk	СР	
Control Systems Theory and Design (L0	0656)	Lecture	2	4	
Control Systems Theory and Design (LC	0657)	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 followin	g learning results			
Professional Competence					
Knowledge Skills	 Students can explain how linear dynamic systems are restates or external excitation as trajectories in state space They can explain the system properties controllability a respectively They can explain the significance of a minimal realisation They can explain observer-based state feedback and how They can explain the z-transform and its relationship with They can explain the experimental identification of ARX solving a normal equation They can explain how a state space model can be constructed. Students can transform transfer function models into state They can assess controllability and observability and cor They can carry out a controller design both in continuous sampling rate They can identify transfer function models and state space 	and observability, and their relations w it can be used to achieve tracking a ut systems the Laplace Transform n models of discrete-time systems models of dynamic systems, and how ucted from a discrete-time impulse res espace models and vice versa struct minimal realisations pus-time and discrete-time domain, a	ship to state feedbac nd disturbance reject v the identification pro sponse	k and state estimatio	
Personal Competence Social Competence Autonomy	 They can carry out all these tasks using standard softwar Students can work in small groups on specific problems to arrive Students can obtain information from provided sources (lecture problems. They can assess their knowledge in weekly on-line tests and the 	at joint solutions. notes, software documentation, expe			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Written exam				
Examination duration and scale	120 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Elec	ctive Compulsory			
Curricula	Electrical Engineering: Core qualification: Compulsory				
	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory				
	Computational Science and Engineering: Specialisation System	s Engineering and Robotics: Elective	Compulsory		
	International Management and Engineering: Specialisation Usatins Engineering: Elective Compulsory				
	International Management and Engineering: Specialisation II. Mo		-		
	Mechanical Engineering and Management: Specialisation Mech				
	Mechatronics: Core qualification: Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Re	generative Medicine: Elective Compu	lsorv		
	Biomedical Engineering: Specialisation Implants and Endoprost		,		
	Lighter and Lighter and Lind problem and Lind problem				
	Biomedical Engineering: Specialisation Medical Technology and	Control Theory: Compulsory			
	Biomedical Engineering: Specialisation Medical Technology and Biomedical Engineering: Specialisation Management and Busin		orv		
	Biomedical Engineering: Specialisation Medical Technology and Biomedical Engineering: Specialisation Management and Busin Product Development, Materials and Production: Core qualificati	ess Administration: Elective Compuls	ory		



Unset Ubesign Typ lecture Independent Study Time 92, Study Time in Lecture 28 Ubesign of the study of the study Time 92, Study Time in Lecture 28 Lecturer Prof. Herbert Werner Language Content State space models and transfer functions, state feedback Control State space models and transfer functions, state feedback Control State space models and transfer functions, state feedback - Coordinate basis, similarity transformations - Solutions of state equations, matrix exponentials, Calay-Hamilton Theorem - Coordinate basis, similarity transformations - Solutions of state feedback control, reference tracking - Transmission zeros - Optimal pole placement - State setimation, observability, Kalman decomposition - Observer-based state feedback control, reference tracking - Transmission zeros - Optimal pole placement symmetric root tocus - Optimal pole placement tor multivariable systems, Collection - Poles and zeros of multivariable systems, LOR design, Kalman filter - Dipital Control - Discrete time state space models, parsigned data systems, choice of sampling rate - System identification and mode			
Hrswk 2 OP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer POL Herbert Werner Language EN Cycte MSe Content State space methods (single-input single output) • State space methods 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, Glibert realization • Poles and zeros of multivariable systems, minimal realization • Closed-loop stability • Pole placement for multivariable systems, LOR design, Kalman filter Digital Control • Discrete-time systems: difference equations and z-transform • Discrete-time systems: difference equations and z-transform • Discrete-time state space models, persistate actitaton • Least squares	Course L0656: Control Systems T	neory and Design	
col 4 Workbade in Hours Independent Study Time 92, Study Time in Lecture 28 Lecture Prof. Herbert Werner Language EN Cycle WiSe Content State space mothods (single-input single-output) - State space mothods (single-input single-output) - State space motels and transfer functions, state feedback - Coordinate basis, similarity transformations - Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem - Solutions of state equations, matrix exponentials - Solutions of state equations, Marin decomposition - Observer-based state leedback control, reference tracking - Transmission zeros - Oplinal pole placement, symmetric root locus Multi-input multi-output systems - Transmission zeros - Oples and zeros of multivariable systems, Killer trealization - Poles and zeros of multivariable systems, LOR design, Kalman filter - Digital Control - Discrete-time systems: difference equations and z-transform - Discrete-time systems: difference equations - Frequency response of sampled data systems, poles and zeros - Frequency response of sampled data systems, poles and zeros - Frequency response of sampled data systems collection - Least squares setimation, ARX models, persistent excitation - Ideatification and mod			
Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Prof. Herbert Werner Language EN Cycle WSe Content State space models and transfer functions, state feedback. • Controllability and pole placement • State equations, matrix exponentials, Caley-Hamilton Theorem • Controllability and pole placement • State estimation, observability, Kalman decomposition • Observer-based state feedback control, reference tracking • Transmission zoros • Optimal pole placement, state space models of multivariable systems, Gilbert realization • Observer-based state feedback control, reference tracking • Transfer function matrices, state space models of multivariable systems, Gilbert realization • Oles and zeros of multivariable systems, minimal realization • Oles and zeros of multivariable systems, LQR design, Kalman filter Digital Control • Discrete-line systems: difference equations and z-transform • Discrete-line systems: difference equations • Using transformation and model order reduction • Least squares estimation, ARX models, persistent excitation • Least squares estimation, ARX models, persistent excitation • Least squares estimation, ARX models, persistent excitation • Least squares estimation, ARX models, persistent excitation •	Hrs/wk	2	
Lecturer Prof. Herbert Werner Language EN Cycle WSe 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 and model order reduction	CP	4	
Language EN Cycle WiSe Content State space methods (single-input single-output) - State space methods 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, ninimal realization - Poles and zeros of multivariable systems, LOR design, Kalman filter Digital Control Discrete-lime systems: difference equations and z-transform - Discrete-lime systems; difference equations and z-transform - Discrete-lime systems; difference equations and z-transform - Discrete-lime system	Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
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 setimation, 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, LCR design, Kalman filter Digital Control • Discrete-time systems: difference equations and z-transform • Discrete-time systems: difference eduction • Least squares estimation, ARX models, persistent excitation • Least squares estimation, ARX models, persistent excitation • Least squares estimation, ARX models, persistent excitation • Least squares estimation and model order reduction • Least squares estination and model order reduction	Lecturer	Prof. Herbert Werner	
Context State space methods (single-input single-output) • State space models and transfer functions, state feedback • Coordinate basis, similarily transformations • Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem • Controllability and pole placement • State settimation, observability, Kalman decomposition • Observer-based state leedback 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, ninimal realization • Coled-loop stability • Pole placement for multivariable systems, LQR design, Kalman filter Digital Control • Discrete-lime systems: difference equations and z-transform • Discrete-lime systems: difference equations and z-transform • Discrete-lime systems: difference equations • Frequency response of 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 <th>Language</th> <th>EN</th>	Language	EN	
 State space models and transfer functions, state feedback Coordinate basis, similarly 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 Closed-loop stability Poles and zeros of 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 Least squares estimation, aRX 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 	Cycle	WiSe	
 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 Closed-loop stability Pole placement for multivariable systems, LOR design, Kalman filter Digital Control 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 Sottware tools 	Content	State space methods (single-input single-output)	
 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 Closed-loop stability Pole placement for multivariable systems, LOR design, Kalman filter Digital Control 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 		· Chata anone modele and transfer functions, state feedback	
 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 state space models, ampled 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, suppace identification Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools 			
 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 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 Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools 			
 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, LOR design, Kalman filter Digital Control Discrete-time systems: difference equations and z-transform 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 and model order reduction Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools 			
 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 Obscrete-time systems: difference equations and z-transform Discrete-time systems: difference equations Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction Least squares estimation, ARX 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 			
 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 systems: difference equations and z-transform Discrete-time systems: difference equations and z-transform 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 			
 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, LOR 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 			
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			
 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 			
 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 			
 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 			
 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 			
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			
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		Digital Control	
 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 			
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		Discrete-time state space models, sampled data systems, poles and zeros	
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			
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			
 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 			
Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools			
Case study • Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools			
Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools			
Software tools		Case study	
		Modelling and multivariable control of a process evaporator using Matlab and Simulink	
- Mattab / Cimulial		Software tools	
• Matao/Simulink		• Matlab/Simulink	
Literature	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		 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	dependent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Module M0867: Productio	n Planning & Control and Digital En	terprise		
Courses				
Title		Тур	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929))	Lecture	2	2
Production Planning and Control (L0930)	Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality Manage	ement		
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed 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 tea	ms and present them to others.		
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following	International Management and Engineering: Spe	cialisation II. Product Development and Production:	Elective Compulsory	
Curricula	Logistics, Infrastructure and Mobility: Specialisati	on Production and Logistics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective Compu	ulsory	
	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			
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory			
	Product Development, Materials and Production:	Specialisation Production: Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisat	ion Product Development and Production: Elective C	compulsory	
	Theoretical Mechanical Engineering: Technical C	Complementary Course: Elective Compulsory		

Course L0932: The Digital Enterpr	ise
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 Plannin	and Control
	Lecture
Hrs/wk	
CP	
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 Plannin	urse 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 Digit	Course L0933: Exercise: The Digital Enterprise			
Тур	Recitation Section (small)			
Hrs/wk	1			
CP	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			



Module M1150: Continuur	m Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534))	Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	Mechanics I			
Knowledge	Mechanics II			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
	The students can set up balance laws and apply basics	of deformation theory to specific aspects, both	in applied contexts a	as in research contexts.
Personal Competence				
Social Competence	The students are able to present solutions to specialists	and to develop ideas further.		
Autonomy	The students are able to assess their own strengths a continuum mechanics on their own.	and weaknesses and to define tasks themselv	es. They can solve	exercises in the area o
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following		n Scientific Computing: Elective Compulsory		
Curricula				
	Mechanical Engineering and Management: Specialisat	ion Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elect	ive Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	ology and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective Compulse	ory	
	Product Development, Materials and Production: Core of	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory		

Course L1533: Continuum Mechan	nics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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 Mechar	nics Exercise
	Recitation Section (small)
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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



Courses				
Title		Тур	Hrs/wk	CP
Electronic Circuits for Medical Application	ns (L0696)	Lecture	2	3
Electronic Circuits for Medical Application	ns (L1056)	Recitation Section (small)	1	2
Electronic Circuits for Medical Application	ns (L1408)	Laboratory Course	1	1
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Fundamentals of electrical engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reach	hed the following learning results		
Professional Competence				
Knowledge				
_		ty of the information transfer by the central nervous		
		of an action potential and its propagation along an a	axon	
		n between neurons and electronic devices		
		s of low-noise amplifiers for medical applications		
	Students can explain the functions of pros			
	 Students are able to discuss the potential 	and limitations of cochlea implants and artificial eye	es	
Skills		ntuellees hohevier of en anti-standard -		
	 Students can calculate the time depende Students can give acception for further important for further impo	provement of low-noise and low-power signal acqu	isition	
	 Students can give scenarios ion uniter initial Students can develop the block diagrams 		ISIUOII.	
	 Students can develop the block diagrams Students can define the building blocks of 			
Personal Competence				
Social Competence	• Students are trained to solve problems in the field of medical electronics in teams together with experts with different background.			th different profession
		fic limitations, so that they can ask for assistance to lear manner and communicate their results in a w	-	involved whenever it
Autonomy	Students can break down their work in appStudents can handle the complex data strength	e status of their knowledge and to define actions for propriate work packages and schedule their work ir uctures of bioelectrical experiments without needin manner in all cases and situations of experimental v	n a realistic way. g support.	ecessary.
	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points	6			
	Oral exam			
	40 min			
	Electrical Engineering: Specialisation Medical Te			
Curricula				
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Compulsory		
	Biomodical Engineering: opeolalication medical			



Course L0696: Electronic Circuits	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	 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 Circuits	Course 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	NN	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Course L1408: Electronic Circuits for Medical Applications Typ Laboratory Course Hrs/wk CP Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN Language Cycle Ocycle Content • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Information transfer by the central nervous system <th></th> <th></th>		
Hrsivik 1 CP 1 Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN 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	Course L1408: Electronic Circuits	for Medical Applications
CP 1 Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN Language EN Cycle WiSe Content • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Inferface 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	Тур	Laboratory Course
Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN Content ViSe 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	Hrs/wk	1
Lecturer NN 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	CP	1
Language EN Cycle WiSe Content • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • 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 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	Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
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	Lecturer	NN
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	Language	EN
 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 	Cycle	WiSe
Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm		 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 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



Module M1151: Material M	odeling			
Courses				
Title		Тур	Hrs/wk	CP
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	mechanics I			
Knowledge	mechanics II			
	continuum mechanics			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multi	dimensional consitutive material laws		
Skills	The students can implement their own material la	ws in finite element codes. In particular, the st	udents can apply the	ir knowledge to vario
	problems of material science and evaluate the corre	esponding material models.		
Personal Competence				
Social Competence	The students are able to develop solutions, to prese	ent them to specialists and to develop ideas furthe	er.	
Autonomy	The students are able to assess their own strengt continuum mechanics on their own.	hs and weaknesses and to define tasks themse	lves. They can solve	exercises in the area
		50		
	Independent Study Time 124, Study Time in Lecture	9 56		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computational Science and Engineering: Specialis			
Curricula	Materials Science: Specialisation Modeling: Electiv			
	Mechanical Engineering and Management: Specia			
	Biomedical Engineering: Specialisation Artificial Or		uisory	
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme		ISOTY	
	Product Development, Materials and Production: Co	ore quantication: Elective Compulsory		

Course L1535: Material Modeling	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Course L1536: Material Modeling	
Тур	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Module M1199: Advanced	Eunctional Materials			
Module Miliss. Advanced				
Courses				
Title		Тур	Hrs/wk	CP
Advanced Functional Materials (L1625)		Lecture	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Fundamentals of Materials Science (I and II)			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	owing learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of advance	ed materials along with their applic	ations in technology, in parti	cular metallic, ceramic
	polymeric, semiconductor, modern composite materials (bion	naterials) and nanomaterials.		
Skills	The students will be able to select material configurations ac	cording to the technical needs and	if necessary to design new	materials considering
Chino	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considerin architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enable			
	them to select optimum materials combinations depending or	•		
Personal Competence				
Social Competence	The students are able to present solutions to specialists and t	to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and weaknesses. 			
	define tasks independently.			
	Independent Study Time 152, Study Time in Lecture 28			
Credit points Examination	6 Written exam			
Examination duration and scale	90 min			
	Materials Science: Core qualification: Compulsory			
Curricula	Mechanical Engineering and Management: Specialisation M	aterials: Elective Compulsory		
Gurreula	Biomedical Engineering: Specialisation Artificial Organs and		Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopr	•		
	Biomedical Engineering: Specialisation Medical Technology		oulsory	
	Biomedical Engineering: Specialisation Management and Bu			
	Theoretical Mechanical Engineering: Technical Complement	tary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materials	s Science: Elective Compulsory		

ourse L1625: Advanced Functional Materials	
Тур	Lecture
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller
Language	DE/EN
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	Wird in der Veranstaltung bekannt gegeben



Courses				
itle		Тур	Hrs/wk	СР
troduction to Biochemistry and Molecu	ılar 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 have r	eached the following learning results		
Professional Competence				
Knowledge	The students can			
	describe basic biomolecules;	ded in the DNA.		
	 explain how genetic information is con explain the connection between DNA 			
	• explain the connection between DNA	and proteins,		
Skills	The students can			
	 recognize the importance of molecula 	r parameters for the source of a disease:		
	describe selected molecular-diagnost	r parameters for the course of a disease;		
	 explain the relevance of these proced 			
Personal Competence				
Social Competence	The students can participate in discussions in	research and medicine on a technical level.		
Autonomy	The students can develop understanding of t	opics from the course, using technical literature, by	themselves	
hatohomy				
Workload in Hours	Independent Study Time 62, Study Time in Le	ecture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German progr	am): Specialisation Mechanical Engineering, Focu	s Biomechanics: Compulse	ory
Curricula	General Engineering Science (German progr	am): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (German progr	am, 7 semester): Specialisation Biomedical Engine	eering: Compulsory	
		am, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechanic	s: Compulsory
	Electrical Engineering: Specialisation Medica			
		am): Specialisation Mechanical Engineering, Focus		ry
		am): Specialisation Biomedical Engineering: Comp	•	. .
		am, 7 semester): Specialisation Mechanical Engine		s: Compulsory
		am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Bion			
	• • •	agement and Business Administration: Elective Col		
		cial Organs and Regenerative Medicine: Elective C		
		cal Technology and Control Theory: Elective Comp	bulsory	
		ants and Endoprostheses: Elective Compulsory		
	Technomathematics: Core qualification: Elec			
	Technomathematics: Specialisation III. Engin	eennu Science: Elective Compulsorv		

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



Module M1333: BIO I: Imp	ants and Fracture Healing				
Courses					
litle		Тур	Hrs/wk	CP	
mplants and Fracture Healing (L0376)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	It is recommended to participate in "Introduction in	to Anatomie" before attending "Implants and Fra	acture Healing".		
Knowledge					
Educational Objectives	After taking part successfully, students have reach	ed the following learning results			
Professional Competence					
Knowledge	The students can describe the different ways how	bones heal, and the requirements for their exist	ence.		
-	The students can name different treatments for the	spine and hollow bones under given fracture n	norphologies.		
Skills	The students can determine the forces acting within	n the human body under quasi-static situations	under specific assumptio	ns.	
Personal Competence					
	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.				
p					
Autonomy	The students can, in groups, solve basic numerica	I modeling tasks for the calculation of internal fo	prces.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following	General Engineering Science (German program):	Specialisation Mechanical Engineering, Focus	Biomechanics: Compulso	ory	
Curricula	General Engineering Science (German program):	Specialisation Biomedical Engineering: Compu	ulsory		
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Te				
	Biomedical Engineering: Specialisation Managem	ent and Business Administration: Elective Com	pulsory		
	Technomathematics: Specialisation III. Engineerin	g Science: Elective Compulsory			



Course L0376: Implants and Fract	ure Healing
•	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
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



Module M1342: Polymers						
0						
Courses						
Title		Тур	Hrs/wk	CP		
Structure and Properties of Polymers (L Processing and design with polymers (L		Lecture Lecture	2	3 3		
	Dr. Hans Wittich	Lecture	L	5		
•						
Admission Requirements	None					
Recommended Previous Knowledge	Basics: chemistry / physics / material science					
Educational Objectives	After taking part successfully, students have reache	d the following learning results				
Professional Competence	Alter taking part successionly, students have reache	a the following learning results				
-	Students can use the knowledge of plastics and	define the personal testing and analysis				
Knowledge	Students can use the knowledge of plastics and	define the necessary testing and analysis.				
	They can explain the complex relationships stru	ucture-property relationship and				
	the interactions of chemical structure of the	polymers, including to explain neighboring	contexts (e.g. sustai	nability, environmenta		
	protection).					
Skills	Students are capable of					
	· · · · · · · · · · · · · · · · · · ·					
	- using standardized calculation methods in a g	given context to mechanical properties (mod	dulus, strength) to calc	ulate and evaluate th		
	different materials.					
	- For mechanical recycling problems selecting a	appropriate solutions and sizing example Stil	fness, corrosion resist	ance.		
Personal Competence						
Social Competence	Students can,					
	- arrive at work results in groups and document	them.				
	- provide appropriate feedback and handle feedb	back on their own performance constructively	V.			
Autonomy	Students are able to,					
	- assess their own strengths and weaknesses					
	- assess their own state of learning in specific t	erms and to define further work steps on this	s basis quided by teach	ners.		
			,			
	- assess possible consequences of their profes	sional activity.				
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56				
Credit points	6					
Examination	Written exam					
Examination duration and scale	180 min					
Assignment for the Following	Materials Science: Specialisation Engineering Mate	erials: Elective Compulsory				
Curricula	Biomedical Engineering: Specialisation Implants and					
	Biomedical Engineering: Specialisation Artificial Or					
	Biomedical Engineering: Specialisation Manageme					
	Biomedical Engineering: Specialisation Medical Te	•••••••••••••••••••••••••••••••••••••••	sory			
	Product Development, Materials and Production: S	· · · · · · · · · · · · · · · · · · ·				
	Product Development, Materials and Production: S					
	Product Development, Materials and Production: S		ompulsory			
	Theoretical Mechanical Engineering: Specialisation	n Materials Science: Elective Compulsory				

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Course L0389: Structure and Prop	erties of Polymers
	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Dr. 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 and de	ourse L1892: Processing and design with polymers		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich		
Language	DE/EN		
Cycle	e		
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
Bioelectromagnetics: Principles and App	lications (L0371)	Lecture	3	5
Bioelectromagnetics: Principles and App		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous	Basic principles of physics			
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	Students can explain the basic principles,	relationships, and methods of bioelectromagneti	cs, i.e. the quantificati	ion and application
-	electromagnetic fields in biological tissue. The	y can define and exemplify the most important phys	ical phenomena and ord	der them correspondi
	to wavelength and frequency of the fields. T	hey can give an overview over measurement and	d numerical techniques	for characterization
	electromagnetic fields in practical application	s . They can give examples for therapeutic and di	agnostic utilization of e	lectromagnetic fields
	medical technology.			
Skills	Students know how to apply various methods t	o characterize the behavior of electromagnetic fields	in biological tissue. In o	order to do this they c
	relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these mode			
	predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in			
	quantitative way. They are able to develop vali	idation strategies for their predictions. They are able	to evaluate the effects of	of electromagnetic fie
	for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence				
Social Competence		related tasks in small groups. They are able to prese	nt their results effectively	y in English (e.g. duri
	small group exercises).			
Autonomy		m subject related, professional publications and rela		
		een their knowledge obtained in this lecture with		
		ctrical engineering / physics). They can commu	inicate problems and	effects in the field
	bioelectromagnetics in English.			
Workload in Hours	Independent Study Time 110, Study Time in Le	acture 70		
Credit points				
Examination				
Examination duration and scale	30-60 minutes			
Assignment for the Following		ve Engineering, Optics, and Electromagnetic Compa	tibility: Elective Compul	sory
Curricula			- P*	-
		pecialisation II. Electrical Engineering: Elective Com	pulsory	
		al Organs and Regenerative Medicine: Elective Com		
	Biomedical Engineering: Specialisation Implan	ts and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medica	al Technology and Control Theory: Elective Compuls	sory	



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	SoSe
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: Bioelectromagnetic	cs: Principles and Applications
Тур	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
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)



Module M1335: BIO II:	Artificial Joint Replacement			
Courses				
ïtle		Тур	Hrs/wk	CP
rtificial Joint Replacement (L1306		Lecture	2	3
Module Respons	ble Prof. Michael Morlock			
Admission Requireme	nts None			
Recommended Prev	us			
Knowle	lge			
Educational Object	After taking part successfully, students have reached	the following learning results		
Professional Compete	ice			
Knowle	lge			
S	ills			
Personal Compete	ice			
Social Compete	nce			
Auton	my			
Workload in Ho	Independent Study Time 62, Study Time in Lecture 2	28		
Credit po	nts 3			
Examina	ion Written exam			
Examination duration and s	ale 90 min			
Assignment for the Follow	ing International Management and Engineering: Specia	lisation II. Process Engineering and Biotech	nnology: Elective Compulso	ry
Curri	ula Materials Science: Specialisation Nano and Hybrid I	Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	ans and Regenerative Medicine: Elective 0	Compulsory	
	Biomedical Engineering: Specialisation Implants and	d Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Teo	chnology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management	nt and Business Administration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective Cor	mpulsory	
	Theoretical Mechanical Engineering: Technical Con	nplementary Course: Elective Compulsory		

Course L1306: Artificial Joint Repl	acement			
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
	Prof. Michael Morlock			
Language				
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)			
	ER 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					
litle		Тур	Hrs/wk	CP	
Robotics and Navigation in Medicine (LC)335)	Lecture	2	3	
Robotics and Navigation in Medicine (LC		Project Seminar	2	2	
Robotics and Navigation in Medicine (LC	1336)	Recitation Section (small)	1	1	
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculated principles of programming, e.g., in Java or solid R or Matlab skills 				
Educational Objectives	After taking part successfully, students have react	ned the following learning results			
Professional Competence					
Knowledge	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in details. Systems be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitation limitation.				
		rigation systems and robotic systems for medical ap	picatoris.		
Personal Competence					
Social Competence	The students discuss the results of other groups,	provide helpful feedback and can incoorporate feed	back into their work.		
Autonomy	The students can reflect their knowledge and doc	ument the results of their work. They can present the	e results in an approp	riate manner.	
Workload in Hours	Independent Study Time 110, Study Time in Lect	ure 70			
Credit points	6				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	Computer Science: Specialisation Intelligence Er	gineering: Elective Compulsory			
Curricula	Electrical Engineering: Specialisation Medical Te	chnology: Elective Compulsory			
	Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
	International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory				
	Product Development, Materials and Production:	Specialisation Production: Elective Compulsory			
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical C	complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisati	on Bio- and Medical Technology: Elective Compute	00/		

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



Course L0338: Robotics and Navigation in Medicine			
Тур	Project Seminar		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		
Course L0336: Robotics and Navi	ourse L0336: Robotics and Navigation in Medicine		
Тур	Recitation Section (small)		

Тур	Recitation Section (smail)
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



on into Medical Technology and Syste	ms			
	Тур	Hrs/wk	CP	
J Systems (L0342)	Lecture	2	3	
Systems (L0343)	Project Seminar	2	2	
I Systems (L1876)	Recitation Section (large)	1	1	
Prof. Alexander Schlaefer				
None				
principles of math (algebra, analysis/calculus)				
principles of stochastics				
principles of programming, R/Matlab				
After taking part successfully, students have reached	the following learning results			
The students can explain principles of medical techr	nology, including imaging systems, computer aid	ed surgery, and medi	cal information system	
They are able to give an overview of regulatory affairs and standards in medical technology.				
The students are able to evaluate systems and medical devices in the context of clinical applications.				
The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.				
The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Independent Study Time 110, Study Time in Lecture 70				
6				
Written exam				
90 minutes				
General Engineering Science (German program): Sr	pecialisation Biomedical Engineering: Compulso	ry		
General Engineering Science (German program, 7 s	semester): Specialisation Biomedical Engineering	: Compulsory		
Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory				
Electrical Engineering: Core qualification: Elective Compulsory				
General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory				
Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory				
Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
		ту.		
	d Systems (L0342) d Systems (L0343) d Systems (L1876) Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reached The students can explain principles of medical techn They are able to give an overview of regulatory affai The students are able to evaluate systems and medi The students describe a problem in medical technol The students can reflect their knowledge and docum Independent Study Time 110, Study Time in Lecture 6 Written exam 90 minutes General Engineering Science (German program): Sp General Engineering Science (German program): Sp General Engineering Science (English program): Sp General Engineering Science and Engineering: Specialiss Computational Science and Engineering: Specialiss Biomedical Engineering: Specialisation Artificial Org Biomedical Engineering: Specialisation Medical Tec	d Systems (L0342) Lecture d Systems (L1876) Project Seminar d Systems (L1876) Recitation Section (large) Prof. Alexander Schlaefer None Principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aid They are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved The students can reflect their knowledge and document the results of their work. They can present the Independent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsor </td <td>Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Rectation Section (large) 1 Prof. Alexander Schlaefer None Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Mattab Ifter taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical they are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. The students can reflect their knowledge and document the results of their work. They can present the results in an approprint heappendent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisat</td>	Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Rectation Section (large) 1 Prof. Alexander Schlaefer None Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Mattab Ifter taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical they are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. The students can reflect their knowledge and document the results of their work. They can present the results in an approprint heappendent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisat	

Course L0342: Introduction into Medical Technology and Systems				
Тур	Lecture			
Hrs/wk				
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 into Medical Technology and Systems		
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	DE	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

course L1876: Introduction into Medical Technology and Systems				
Тур	Recitation Section (large)			
Hrs/wk	1			
CP	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.			



Iodule M0752: Nonlinear	Dynamics			
Courses				
Title		Тур	Hrs/wk CP	
Nonlinear Dynamics (L0702)		Lecture	4 6	
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and co	oncepts in Nonlinear Dynamics and to develop	and research new terms and concepts.	
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Airc	craft Systems: Elective Compulsory		
Curricula	Computational Science and Engineering: Specia	alisation Scientific Computing: Elective Compu	Isory	
	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			
	Biomedical Engineering: Specialisation Artificial	• •	Compulsory	
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			
	Product Development, Materials and Production			
	Theoretical Mechanical Engineering: Technical			
	Theoretical Mechanical Engineering: Core quali	tication: Elective Compulsory		

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



Courses					
Title		Тур	Hrs/wk	СР	
Semiconductor Technology (L0722)		Lecture	4	5	
Semiconductor Technology (L0723)		Laboratory Course	2	2	
Module Responsible					
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semic	conductor devices			
Educational Objectives	After taking part successfully, students have reached the	following learning results			
Professional Competence	Alter laking part successiony, students have reached the	following learning results			
Knowledge					
, nonicago					
	Students are able				
	to describe and to explain current fabrication techniq	ues for Si and GaAs substrates,			
	• to discuss in details the relevant fabrication process	ses, process flows and the impact thereof o	n the fabrication of sen	niconductor devices an	
	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 semico	onductor devices.			
Personal Competence					
Social Competence					
	Students are able to prepare and perform their lab expen	riments in team work as well as to present a	nd discuss the results i	n front of audience.	
Autonomy	None				
	Independent Study Time 126, Study Time in Lecture 84				
Credit points					
Examination					
Examination duration and scale					
		and Microsystems Technology: Elective Con	npulsory		
Curricula					
	Biomedical Engineering: Specialisation Implants and En	idoprostneses: Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno		ory		



Course L0722: Semiconductor Tec	shnology				
Тур	Lecture				
Hrs/wk	4				
CP	5				
Workload in Hours	idependent Study Time 94, Study Time in Lecture 56				
Lecturer	of. 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) Water 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, kinetics, 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 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: excimer laser light source, immersion lithography and phase shift lithography, electron 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, bipola				
Literature	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: Semiconductor Tee	irse L0723: Semiconductor Technology			
Тур	Laboratory Course			
Hrs/wk	2			
CP	2			
Workload in Hours	ependent 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: Humanoid	Robotics			
Courses				
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk	CP 2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				-
Knowledge	• Otudanta ann amhain humannaid mhata			
	Students can explain humanoid robots.Students learn to apply basic control concepts for	different tasks in humanoid relatios		
	 Students learn to apply basic control concepts for 	unierent tasks in numariolo robotics.		
Skills	 Students acquire knowledge about selected aspe 	cts of humanoid robotics based on spe	ecified literature	
	 Students generalize developed results and prese 			
	 Students practice to prepare and give a presentat 			
Personal Competence				
Social Competence	 Students are capable of developing solutions in ir 	nterdisciplinary teams and present then	n	
	 They are able to provide appropriate feedback an 			
Autonomy	 Students evaluate advantages and drawbacks of 	different forms of presentation for speci	ific tasks and select the best	solution
	 Students familiarize themselves with a scientific 			
	scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control and Power	Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Systems and Rot	potics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Eng			
	Biomedical Engineering: Specialisation Medical Technol			
	Biomedical Engineering: Specialisation Management and		mpulsory	
	Theoretical Mechanical Engineering: Technical Complem			
	Theoretical Mechanical Engineering: Core qualification: I	Elective Compulsory		

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



ourses					
itle		Тур	Hrs/wk	CP	
inear and Nonlinear System Identification	on (L0660)	Lecture	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	2 1				
Knowledge	Classical control (frequency response	e, root locus)			
	State space methods				
	Discrete-time systems				
	Linear algebra, singular value decom				
	 Basic knowledge about stochastic pro 	ocesses			
Educational Objectives	After taking part successfully, students have	reached the following learning results			
Professional Competence					
Knowledge		mowerk of the prediction error method and its apr	lighting to a variaty of line	or and poplinger me	
		mework of the prediction error method and its app	nication to a variety of line	ai anu nonimear mu	
	 structures They can explain how multilayer perceptron networks are used to model nonlinear dynamics 				
		e predictive control scheme can be based on neura			
		e identification and its relation to Kalman realisatio			
			in theory		
Skills			C		
	 Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynam systems 				
	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 				
				ystems	
	 They can do the above using standar 	d software tools (including the Matlab System Ident	incation looidox)		
Personal Competence					
Social Competence	Students can work in mixed groups on specif	fic problems to arrive at joint solutions.			
Autonomy	Students are able to find required informati	on in sources provided (lecture notes, literature, s	oftware documentation) a	nd use it to solve ai	
hatohomy	problems.		ionation documentation) a		
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28			
Credit points					
Examination					
Examination duration and scale					
Assignment for the Following					
Curricula	1 0 ,				
	Mechatronics: Specialisation System Design				
		icial Organs and Regenerative Medicine: Elective C	ompulsory		
		ants and Endoprostheses: Elective Compulsory			
		lical Technology and Control Theory: Compulsory			
		agement and Business Administration: Elective Co	mpulsory		
	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory			

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



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Courses					
Title		Тур	Hrs/wk	CP	
Optimal and Robust Control (L0658) Optimal and Robust Control (L0659)		Lecture Recitation Section (small)	2 2	3 3	
Module Responsible	Prof. Herbert Werner	neclation Section (Smail)	2	5	
Admission Requirements	None				
Recommended Previous	None				
Knowledge	Classical control (frequency response, root loc	us)			
	State space methods				
	Linear algebra, singular value decomposition				
Educational Objectives	After taking part successfully, students have reached t	he following learning results			
Professional Competence					
Knowledge					
	Students can explain the significance of the ma		ems.		
	They can explain the duality between optimals They can explain how the U2 and U infinity as				
		rms are used to represent stability and performan			
	 They can explain how an LOG design problem They can explain how model uncertainty can be 	can be formulated as special case of an H2 des	•		
	 They can explain how model directionly can be small g 		-	rmance for an uncer	
	plant.				
	 They understand how analysis and synthesis of 	conditions on feedback loops can be represented	l as linear matrix ine	qualities.	
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 too				
	for solving it.				
	• They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitive				
	functions, and of carrying out a mixed-sensitivity design.				
	• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller.				
	They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers to achieve the area.				
	solving them.				
	 They can carry out all of the above using stand 	ard software tools (Matlab robust control toolbox).		
Personal Competence					
Social Competence	e Students can work in small groups on specific problems to arrive at joint solutions.				
Autonomy	Students are able to find required information in sou	irces provided (lecture notes, literature, softwar	e documentation) a	nd use it to solve gi	
	problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6			
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engine	• • •			
Curricula	Electrical Engineering: Specialisation Control and Pov				
	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
			Jompulsory		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Orga		sorv		
	Biomedical Engineering: Specialisation Annotal Orga Biomedical Engineering: Specialisation Implants and				
	Biomedical Engineering: Specialisation Implants and				
	Biomedical Engineering: Specialisation Management				
	Product Development, Materials and Production: Spec				
	Product Development, Materials and Production: Spec				
	Product Development, Materials and Production: Spec	cialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Comp	lementary Course: Elective Compulsory			
	5 5 I				



Course L0658: Optimal and Robus				
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	lependent 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	
CP	3	
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28	
Lecturer	of. Herbert Werner	
Language		
Cycle	Cycle SoSe	
Content	See interlocking course	
Literature	See interlocking course	



Courses					
Title		Тур	Hrs/wk	CP	
Feedback Control in Medical Technolog		Lecture	2	3	
Module Responsible	Prof. Olaf Simanski				
Admission Requirements	None				
Recommended Previous	Basics in Control, Basics in Physiology				
Knowledge					
Educational Objectives	After taking part successfully, students have re	ached the following learning results			
Professional Competence					
Knowledge	The lecture will introduce into the fascinating	area of medical technology with the engineering	point of view. Fundamenta	als in human physiolo	
	will be similarly introduced like knowledge in o	control theory.			
	Internal control loops of the human body wil	he discussed in the same way like the design	of external closed loop s	vetem to example in	
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system to example in anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated.				
	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 specific pro	blems in small groups and present their results (e	a during project week)		
Social Competence	Sudents can develop solutions to specific pro	bients in sman groups and present their results (e	.g. duning project week)		
Autonomy	Students are able to find necessary literature	and to set it into the context of the lecture. They	are able to continuously e	valuate their knowled	
	and to take control of their learning process. T	ney can combine knowledge from different course	es to form a consistent whol	е.	
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28			
Credit points	3				
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory			
Curricula	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory			
	Biomedical Engineering: Specialisation Artific	al Organs and Regenerative Medicine: Elective C	Compulsory		
	Biomedical Engineering: Specialisation Implan	nts and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Compulsory			
	Biomedical Engineering: Specialisation Mana	nement and Business Administration: Elective Co	mpulsory		

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



Module M1143: Mechanica	al Design Methodology				
Courses					
Title		Тур	Hrs/wk	СР	
Mechanical Design Methodology (L1523	3)	Lecture	3	4	
Mechanical Design Methodology (L1524	ł)	Recitation Section (small)	1	2	
Module Responsible	Prof. Josef Schlattmann				
Admission Requirements	None				
Recommended Previous					
Knowledge					
Educational Objectives	After taking part successfully, students have r	eached the following learning results			
Professional Competence					
Knowledge	Science-based working on product design considering targeted application of specific product design techniques				
01.11					
Skills Creative handling of processes used for scientific preparation and formulation of complex product design problems / Applica					
	design techniques following theoretical aspects.				
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56			
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	International Management and Engineering:	Specialisation II. Product Development and Production	: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory			
	Biomedical Engineering: Specialisation Artific	cial Organs and Regenerative Medicine: Elective Comp	oulsory		
	Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective Compulso	ory		
	Biomedical Engineering: Specialisation Mana	agement and Business Administration: Elective Compu	lsory		
	Product Development, Materials and Product	ion: Specialisation Product Development: Elective Corr	pulsory		
	Product Development, Materials and Product	ion: Specialisation Production: Elective Compulsory			
	Product Development, Materials and Product	ion: Specialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Special	isation Product Development and Production: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technic	al Complementary Course: Elective Compulsory			

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



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



ourses				
le		Тур	Hrs/wk	CP
urketing (Innovation Marketing / Sales	and Services) (L0862)	Problem-based Learning	5	6
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous				
Knowledge	Module International Business Basia understanding of husiness	ion principlos (stratogio plopping, docision (theory project may	accoment internet
	 Basic understanding of business administrati business) 	on principles (strategic planning, decision	meory, project mai	lagement, internati
	 Bachelor-level Marketing Knowledge (Marketing 	Instruments Market and Competitor Strategies	Basics of Buying F	Sehavior)
	 Understanding of differences in the market introd 		, 240.00 01 24Jiiig 2	Jonarion,
	Unerstanding the differences beweetn B2B and			
	 Understanding of the importance of managing in 	novation in global industrial markets		
	Good English proficiency; presentation skills			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence	Other standing to the standing of the standard standing of			
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innov	ative industrial goods and services		
	The importance of product-related and independ	dent services		
	 Approaches for analyzing the current market situ 	ation and the future market development		
	The gathering of information about future custom			
	Concepts and approaches to integrate lead use			
	Approaches and tools for ensuring customer-ori			
	 Marketing mix elements that take into considerat Pricing methods for new products and services 	tion the specific requirements and challenges o	i innovative product	s and services
	The organization of complex sales forces and personal selling			
	Communication concepts and instruments for ne			
Skills	Based on the acquired knowledge students will be able			
	Design and to evaluate decisions regarding man Analyze markets by applying market and technol			
	 Analyze markets by applying market and techno Conduct forecasts and develop compelling scen 			
	 Translate customer needs into concepts, prote 		ly apply advanced	methods for custo
	oriented product and service development			
	 Use adequate methods to foster efficient diffusio 	n of innovative products and services		
	 Choose suitable pricing strategies and commun 			
	Make strategic sales decisions for products and			
	Apply methods of sales force management (i.e. a)	customer value analysis)		
D 10 1				
Personal Competence	The students will be able to			
Social Competence	The students will be able to			
	have fruitful discussions and exchange argumer	nts		
	 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			
	Accurrent provide data independent in the second seco	a contact and to may this knowledge and all	ow complex	a fielde
	 Acquire knowledge independently in the specific Consider proposed business actions in the field 		ew complex problem	n tielas.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisa	•	sory	
Curricula	Mechanical Engineering and Management: Specialisati			
	Biomedical Engineering: Specialisation Artificial Organs		sory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technology			



	ion Marketing / Sales and Services)
Тур	Problem-based Learning
Hrs/wk CP	5
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	I. Introduction I. 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
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Kotler, P., Keller, K. L. (2006). Marketing Management, 12 th edition, Pearson Prentice Hall, New Jersey Bo Edvardsson et. al. (2006) Involving Customers in New Service Development, London Joe Tidd & Frank M. Hull (Editors) (2007) Service Innovation, London Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008



Courses				
litle		Тур	Hrs/wk	CP
Bioprocess Engineering - Fundamentals	(L0841)	Lecture	2	3
Bioprocess Engineering- Fundamentals		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental F	Practical Course (L0843)	Laboratory Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "fundamer	itals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students are able to describe the basic concepts of I	pioprocess engineering. They are able to classif	/ different types of I	inetics for enzymes
	microorganisms, as well as to differentiate different	types of inhibition. The parameters of stoichiom	etry and rheology c	an be named and m
	transport processes in bioreactors can be explained	d. The students are capable to explain fundam	ental bioprocess m	anagement, steriliza
	technology and downstream processing in detail.			
Skills	After successful completion of this module, students s	hould be able to		
	 describe different kinetic approaches for grow 	th and substrate-uptake and to calculate the corre	sponding paramete	ers
	 predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentatio 			
	process			
	analyze bioprocesses on basis of stoichiometer	ry and to set up / solve metabolic flux equations		
	 distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare 			
	them as well as to apply them to current biotechnical problem			
	 propose solutions to complicated biotechnology 	gical problems and to deduce the corresponding	models	
	 to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. 			
	 to document and discuss their procedures as 			
Personal Competence				
-	After completion of this module participants should b	a able to debate technical questions in small tea	me to ophanco tho	ability to take positio
Social Competence	their own opinions and increase their capacity for teal			ability to take positio
	and increase their capacity for teal	nwork in engineering and scientific environmenta		
Autonomy	After completion of this module participants will be at	ble to solve a technical problem in a team indepe	ndently by organizi	ng their workflow and
	present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): Spo	ecialisation Process Engineering: Compulsory		
Curricula	General Engineering Science (German program): Spo			
	General Engineering Science (German program, 7 se			
	General Engineering Science (German program, 7 se	, , , , , , , , , , , , , , , , , , , ,	Compulsory	
	Bioprocess Engineering: Core qualification: Compuls	•		
	General Engineering Science (English program): Spe			
	General Engineering Science (English program): Spe			
	General Engineering Science (English program, 7 se	, ,		
	General Engineering Science (English program, 7 se		Compulsory	
	Biomedical Engineering: Specialisation Artificial Orga	•		
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Management		ory	
	Technomathematics: Specialisation III. Engineering S			
	Process Engineering: Core qualification: Compulsory			



Course L0841: Bioprocess Engine	ering - Fundamentals		
Тур	sture		
Hrs/wk			
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) Technology of sterilization (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 Engine	ering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
CP	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 Engine	ering - Fundamental Practical Course
Тур	Laboratory Course
Hrs/wk	2
CP	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 Physiology (L0385)		Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Dr. Roger Zimmermann	Lecture	2	5
Admission Requirements	None			
Recommended Previous	None			
Knowledge	None			
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 me 			
	 describe physiological relations in set 	elected fields of muscle, heart/circulation, neuro- and	l sensory physiology.	
Skills	The students can describe the effects of bas	sic bodily functions (sensory, transmission and prod	cessing of information, de	velopment of forces a
	vital functions) and relate them to similar tech	hnical systems.		
Personal Competence				
Social Competence	The students can conduct discussions in res	earch 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 question	ns arising in the course and other physiological area	s using tooppical literatur	a by thomsolvos
Autonomy	The students can derive answers to question	is ansing in the course and other physiological area	s, using technical interation	e, by memserves.
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German prog	ram): Specialisation Mechanical Engineering, Focus	s Biomechanics: Compuls	ory
Curricula	General Engineering Science (German prog	ram): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (German prog	ram, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	General Engineering Science (German prog	ram, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechani	cs: Compulsory
	Electrical Engineering: Specialisation Medic	al Technology: Elective Compulsory		
	General Engineering Science (English progr	ram): Specialisation Mechanical Engineering, Focus	Biomechanics: Compulse	ory
	General Engineering Science (English progr	ram): Specialisation Biomedical Engineering: Comp	ulsory	
	General Engineering Science (English progr	ram, 7 semester): Specialisation Mechanical Engine	ering, Focus Biomechanic	s: Compulsory
	General Engineering Science (English progr	ram, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Bior	mechanics: Compulsory		
	Biomedical Engineering: Specialisation Med	lical Technology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Man	agement and Business Administration: Elective Cor	mpulsory	
	Biomedical Engineering: Specialisation Artif	icial Organs and Regenerative Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Impl	ants and Endoprostheses: Elective Compulsory		
	Technomathematics: Core qualification: Elec	ctive Compulsory		
	Technomathematics: Specialisation III. Engin	peering Science: Elective Compulsory		

Course L0385: Introduction to Phy	siology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Roger Zimmermann
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



Module M1277: MED I: Intr	roduction to Anatomy
Courses	
Title	Typ Hrs/wk CP
Introduction to Anatomy (L0384)	Lecture 2 3
Module Responsible	Prof. Udo Schumacher
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 basal structures and functions of internal organs and the musculoskeletal system.
	The students can describe the basic macroscopy and microscopy of those systems.
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explai
Onno	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 acquire the relevan
natonomy	knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
Curricula	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: 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

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Tup	Lecture	
Hrs/wk		
CP		
Workload in Hours		
Lecturer		
Language		
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/Michael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag Stuttgart, 2012	



Courses				
Title		Тур	Hrs/wk	CP
Experimental Methods in Biomechanics	(L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implantate und F	rakturheilung" before attending "Experime	ntelle 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 bo	nes heal, and the requirements for their ex	distence.	
	The students can name different treatments for the s	pine and hollow bones under given fracture	e morphologies.	
	The students can describe different measurement te	abniques for foress and movements, and a	hadde the adaguate technique	o for a given took
	The students can describe diletent measurement te	childres for forces and movements, and c	noose the adequate techniqu	ie ior a given task.
Skills	The students can describe the basic handling of sev	eral experimental techniques used in biom	echanics.	
Deve and Commetones				
Personal Competence Social Competence	The students can, in groups, solve basic experiment	al tooko		
Social Competence	The students can, in groups, solve basic experiment	ai lasks.		
Autonomy	The students can, in groups, solve basic experiment	al tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8		
Credit points	3	5		
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): Sp	occiplication Mochanical Engineering For	us Biomochanics: Compulsor	2/
Curricula	General Engineering Science (German program): Sp			у
ourroua	General Engineering Science (German program, 7 s	• •		: Compulsory
	General Engineering Science (German program, 7 s			in compared by
	General Engineering Science (English program): Sp	, ,		
	General Engineering Science (English program): Sp	• •		v
	General Engineering Science (English program, 7 s	• •		
	General Engineering Science (English program, 7 s	, , , , , , , , , , , , , , , , , , , ,		
	Mechanical Engineering: Specialisation Biomechan	, ,	compared y	
	Biomedical Engineering: Specialisation Artificial Org		Compulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tec		noulsory	
	Biomedical Engineering: Specialisation Managemen			
	Technomathematics: Specialisation III. Engineering			

Course L0377: Experimental Meth	Course 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	



0				
Courses		-		
Fitle ntroduction to Radiology and Radiation	Therapy (L0383)	Typ Lecture	Hrs/wk 2	СР 3
Module Responsible				-
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Therapy The students can distinguish different types of currer	tly used equipment with respect to its use ir	n radiation therapy.	
	The students can explain treatment plans used in rad	diation therapy in interdisciplinary contexts	(e.g. surgery, internal medio	sine).
	The students can describe the patients' passage f	rom their initial admittance through to foll	ow-up care.	
	Diagnostics			
	The students can illustrate the technical base conce imaging techniques (CT, MRT, US).	pts of projection radiography, including ang	giography and mammograp	hy, as well as section
	The students can explain the diagnostic as well as the	erapeutic use of imaging techniques, as we	ell as the technical basis for	those techniques.
	The students can choose the right treatment method	depending on the patient's clinical history a	and needs.	
	The student can explain the influence of technical er	rors on the imaging techniques.		
	The student can draw the right conclusions based or	n the images' diagnostic findings or the erro	r protocol.	
Skills	s Therapy The students can distinguish curative and palliative situations and motivate why they came to that conclusion.			
	The students can develop adequate therapy concep	ts and relate it to the radiation biological as	pects.	
	The students can use the therapeutic principle (effec	ts vs adverse effects)		
	The students can distinguish different kinds of radia the energy needed in that situation (irradiation plann		on the situation (location of	the tumor) and choo
	The student can assess what an individual psycho groups, social services, psycho-oncology).	social service should look like (e.g. follow-	up treatment, sports, socia	l help groups, self-h
	Diagnostics			
	The students can suggest solutions for repairs of ima	iging instrumentation after having done erro	or analyses.	
	The students can classify results of imaging technique and pathophysiology.	ies according to different groups of disease	s based on their knowledg	e of anatomy, patholo
Personal Competence				
Social Competence	The students can assess the special social situation The students are aware of the special, often fear-dor them appropriately.			neasures and can m
Autonomy	The students can apply their new knowledge and sk The students can introduce younger students to the			
	The students are able to access anatomical knowle	dge by themselves, can participate compet	ently in conversations on th	e topic and acquire
	relevant knowledge themselves.			
Workload in Hours		8		
Credit points	3 Written even			
Examination Examination duration and scale	Written exam 90 minutes			
Assignment for the Following	General Engineering Science (German program): Sp	pecialisation Mechanical Engineering, Focu	s Biomechanics: Compulse	iry
Curricula	General Engineering Science (German program): Sp			
	General Engineering Science (German program, 7 s	emester): Specialisation Biomedical Engine	eering: Compulsory	
	General Engineering Science (German program, 7 s		eering, Focus Biomechanic	s: Compulsory
	Electrical Engineering: Specialisation Medical Tech		Biomochanica Ocast	n/
	General Engineering Science (English program): Sp General Engineering Science (English program): Sp			ı y
	General Engineering Science (English program, 7 sc			s: Compulsory
	General Engineering Science (English program, 7 s		-	
	Mechanical Engineering: Specialisation Biomechan			
	Biomedical Engineering: Specialisation Medical Tec	hnology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Managemen			

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 TUHH

Course L0383: Introduction to Rad	liology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	
-	
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 f ür 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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Knowledge After taking Educational Objectives After taking Professional Competence After succession Knowledge After succession Skills After succession Skills After succession Skills After succession Skills After succession Scial Competence Students and stu	tical course Introduction to cell culture" particip part successfully, students have reached the fol sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	llowing learning results able to describe the basic methods of i	regenerative medicine an ew of methods for the cu	
Regenerative Medicine (L0347) Prof. Ralf P	tical course Introduction to cell culture" particip part successfully, students have reached the fol sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	Seminar pation in lecture "Regenerative medicine llowing learning results able to describe the basic methods of r g. They are able to give a basic overvi	2 g" regenerative medicine and ew of methods for the cu	3 nd to explain the use o
Module Responsible Prof. Raif Professional Competence None Educational Objectives For the "Prantic Professional Competence After success the tissue of human cells Professional Competence Knowledge After success the tissue of human cells Skills After success • able Skills After success • able Social Competence Students ar Students ar Autonomy After complementation After complementation Module Competence Students ar Students ar Social Competence Students ar Students ar Mutonomy After complementation After complementation	tical course Introduction to cell culture" particip part successfully, students have reached the fol sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	pation in lecture "Regenerative medicine llowing learning results able to describe the basic methods of i g. They are able to give a basic overvi	egenerative medicine and a set of methods for the cu	nd to explain the use o
Admission Requirements None Recommended Previous For the "Prance Knowledge After taking Educational Objectives After success Knowledge After success Skills After success • able • able • able • able • able • able Social Competence Students and Students and Students and Autonomy After complementation Workload in Hours Independer	tical course Introduction to cell culture" particip part successfully, students have reached the fol sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	llowing learning results able to describe the basic methods of g. They are able to give a basic overvi	regenerative medicine an ew of methods for the cu	
Recommended Previous Knowledge For the "Pra- Knowledge Educational Objectives After taking Professional Competence Knowledge After succes the tissue of human cells Skills After succes Skills After succes • able • able • able • able • able • able • Students an Students an Students an Students an After comple After comple After comple presentation Workload in Hours Independer Credit points 6	part successfully, students have reached the fol sful completion of the module students will be sful sor different methods of tissue engineering sful completion of the module students are	llowing learning results able to describe the basic methods of g. They are able to give a basic overvi	regenerative medicine an ew of methods for the cu	
Knowledge After taking Educational Objectives After taking Professional Competence After succession Knowledge After succession Knowledge After succession Skills Students and succession Social Competence Students and succession Students and succession Students and succession Autonomy After compliants and succession Morkload in Hours Independent Credit points 6	part successfully, students have reached the fol sful completion of the module students will be sful sor different methods of tissue engineering sful completion of the module students are	llowing learning results able to describe the basic methods of g. They are able to give a basic overvi	regenerative medicine an ew of methods for the cu	
Educational Objectives After taking Professional Competence Knowledge After succes Knowledge After succes the tissue of human cells Skills After succes Skills After succes able able able able Social Competence Students an Students an Autonomy After complipresentation Students an Morkload in Hours Independer Credit points 6 6	sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	able to describe the basic methods of i g. They are able to give a basic overvi	ew of methods for the cu	
Professional Competence After succes Knowledge After succes the tissue of human cells Skills After succes Skills After succes • able • able • able • able • able • able • Social Competence Students an Students an Students an Autonomy After comple Workload in Hours Independer Credit points 6	sful completion of the module students will be ills for different methods of tissue engineering sful completion of the module students are	able to describe the basic methods of i g. They are able to give a basic overvi	ew of methods for the cu	
Knowledge After success human cells human cells Skills After success Skills After success Personal Competence able Social Competence Students and Students and Students and Atter compliant After compliant Mutonomy After compliant Workload in Hours Independent G Students and students	ells for different methods of tissue engineering	g. They are able to give a basic overvi	ew of methods for the cu	
the tissue of human cells Skills After success Skills After success Personal Competence able Social Competence Students and stude	ells for different methods of tissue engineering	g. They are able to give a basic overvi	ew of methods for the cu	
human cells Skills After success After success able able able able able Social Competence Students and Social Competence Students and Autonomy After compliants After compliants Independent Workload in Hours Independent Credit points 6	sful completion of the module students are			ultivation of animal an
Skills After success After success able able able able able Social Competence Students and students a	sful completion of the module students are	presentation of relevant up-to-date data		
Personal Competence able Social Competence Students ar Students ar Students ar Autonomy After complipresentation Workload in Hours Independer Credit points 6		presentation of relevant up-to-date data		
Personal Competence able Social Competence Students ar Students ar Students ar Autonomy After complipresentation Workload in Hours Independer Credit points 6		presentation of relevant up-to-date data		
Personal Competence able Social Competence Students and Students a	a use medical detebases for acquirierung and	presentation of relevant up-to-date data		
Personal Competence Students ar Social Competence Students ar Students ar Students ar Autonomy After compli- presentation Workload in Hours Independer Credit points 6	o use medical databases for acquirterung and		a independently	
Personal Competence Students ar Social Competence Students ar Students ar Students ar Autonomy After complipresentation Workload in Hours Independer Credit points 6	to present their work results in the form of prese	entations		
Social Competence Students and Students and Students and Autonomy After compling Workload in Hours Independent Credit points 6	to carry out basic cell culture methods and the o	corresponding analysis independently		
Social Competence Students and Students and Students and Autonomy After compling Workload in Hours Independent Credit points 6				
Autonomy Students and After complementation Morkload in Hours Independent Credit points 6	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			
Autonomy After complementation Workload in Hours Independer Credit points 6	-	-		
After compl presentation Workload in Hours Independen Credit points 6	able to reflect their work orally and discuss it w	vith other students and teachers.		
After compl presentation Workload in Hours Independen Credit points 6				
After compl presentation Workload in Hours Independen Credit points 6				
Workload in Hours Independer Credit points 6				
Workload in Hours Independer Credit points 6	tion of this module, participants will be able to	solve a technical problem in teams of	approx. 2-4 persons ind	lependently including
Credit points 6	of the results.			
Credit points 6				
	Independent Study Time 110, Study Time in Lecture 70			
Examination Presentatio				
	Oral presentation + discussion (30 min) + protocol internship			
	() 1	• • • •		
	Engineering: Specialisation Artificial Organs an			
Biomedical Biomedical	Engineering: Specialisation Artificial Organs an Engineering: Specialisation Implants and Endo	y and Control Theory: Elective Compute	•	

Course L0350: Practical Course In	stroduction to Cell Culture
Тур	Laboratory Course
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner
Language	DE
Cycle	SoSe
Content	Introduction to basic skills for cultivation of mammalian cells
	compact practical course
Literature	
	Lindl, T. und Gstraunthaler, G.: Zell- und Gewebekultur. Von den Grundlagen zur Laborbank. Spektrum Akademischer Verlag; 6. Auflage 2008.

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Course L0347: Regenerative Medi	
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE/EN
Cycle	SoSe
Content	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), Jör Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540



Courses				
litle		Тур	Hrs/wk	CP
Advanced Topics in Control (L0661)			2	3 3
Advanced Topics in Control (L0662)	Duraf Llaula ant Manus au	Recitation Section (small)	2	3
	Prof. Herbert Werner			
	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sensitivity design, linear r	natrix inequalities		
-	After taking part augeoconfully, atudente have reached the f			
Educational Objectives	After taking part successfully, students have reached the fe	onowing rearring results		
Professional Competence Knowledge				
Kilowieuge	Students can explain the advantages and shortcor	nings of the classical gain scheduling appro	bach	
	• They can explain the representation of nonlinear s	systems in the form of quasi-LPV systems		
	They can explain how stability and performance co	onditions for LPV systems can be formulated	as LMI conditions	
	They can explain how gridding techniques can be			
	They are familiar with polytopic and LFT represent	tations of LPV systems and some of the bas	ic synthesis technique	es associated with ea
	of these model structures			
	.			
	Students can explain how graph theoretic concept		topology of multiagen	t systems
	They can explain the convergence properties of fill They can explain an element of the set			
	They can explain analysis and synthesis condition	s for formation control loops involving either	r L II or LPV agent mo	dels
	Students can explain the state space represent	tation of spatially invariant distributed sy	stoms that are discr	otized according to a
	 Students can explain the state space represen actuator/sensor array 	lation of spatially invariant distributed sys	stems that are disch	elized according to a
	 They can explain (in outline) the extension of the b 	ounded real lemma to such distributed svs	tems and the associat	ted synthesis condition
	for distributed controllers	sounded real lenima to such distributed sys		ted synthesis condition
Skills	 Students are capable of constructing LPV mod 	lels of nonlinear plants and carry out a	mixed-sensitivity de	sign of gain-schedule
	controllers; they can do this using polytopic, LFT of		mixed sensitivity dec	sign of gain solicadi
	 They are able to use standard software tools (Math 	-		
	.,			
	 Students are able to design distributed formation 	n controllers for groups of agents with eith	er LTI or LPV dynam	nics, using Matlab too
	provided			, 0
	 Students are able to design distributed controllers 	for spatially interconnected systems, using t	the Matlab MD-toolbo	x
	Ŭ			
Personal Competence				
,	Students can work in small groups and arrive at joint result			
Autonomy	Students are able to find required information in source	s provided (lecture notes, literature, softwa	re documentation) ar	nd use it to solve give
	problems.			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
	Oral exam			
	30 min			
	Computer Science: Specialisation Intelligence Engineerin			
Curricula	Electrical Engineering: Specialisation Control and Power			
	Electrical Engineering: Specialisation Control and Power			
	Aircraft Systems Engineering: Specialisation Aircraft Syste		_	
	Computational Science and Engineering: Specialisation S		Compulsory	
	International Management and Engineering: Specialisation			
	Mechatronics: Specialisation System Design: Elective Cor			
	Mashahadaa Oosadah di badhi soo soo si Titi			
	Mechatronics: Specialisation Intelligent Systems and Rob			
	Biomedical Engineering: Specialisation Implants and End	oprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and End Biomedical Engineering: Specialisation Artificial Organs a	oprostheses: Elective Compulsory and Regenerative Medicine: Elective Compu		
	Biomedical Engineering: Specialisation Implants and End Biomedical Engineering: Specialisation Artificial Organs a Biomedical Engineering: Specialisation Management and	oprostheses: Elective Compulsory and Regenerative Medicine: Elective Compu I Business Administration: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Implants and End Biomedical Engineering: Specialisation Artificial Organs a	oprostheses: Elective Compulsory and Regenerative Medicine: Elective Compu I Business Administration: Elective Compulso ogy and Control Theory: Elective Compulsor	sory	



Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Prof. Herbert Werner
Language	EN
Cycle	
Content	
	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Control of Spatially Interconnected Systems
	- Multidimensional signals, I2 and L2 signal norm
	- Multidimensional systems in Roesser state space form
	- Extension of real-bounded lemma to spatially interconnected systems
	- LMI-based synthesis of distributed controllers
	- Spatial LPV control of spatially varying systems
	- Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	
	Werner, H., Lecture Notes "Advanced Topics in Control"

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



Module M1227: Lecture Ti	issue Engineering - Regenerative Medicine			
Courses				
Title		Тур	Hrs/wk	СР
Lecture Tissue Engineering - Regeneral	tive Medicine (L1664)	Seminar	2	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	After successful completion of the module students can out explain the basic udnerlying principles of the discussed topic		e Engineering and regenerati	ve medicine and car
Skills	After successful completion of the module students will be regenerative medicine.	able to to analyse and evaluate	current research topics for Tis	sue Engineering and
Personal Competence				
Social Competence	Students are able to work together as a team with several students to solve given tasks and discuss their results in the plenary and to defend then		y and to defend them.	
Autonomy	The students are able to present independently the results of	their subtasks in a presentation		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6			
Examination	Written elaboration			
Examination duration and scale	written report (10 pages)			
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Compute	sory	
Curricula	Biomedical Engineering: Specialisation Implants and Endopr	ostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective C	ompulsory	

Course L1664: Lecture Tissue Eng	gineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, 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



Specialization Artificial Organs and Regenerative Medicine

Module M0623: Intelligent	Systems in Medicine			
Courses				
Title		Тур	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)		Lecture	2	3
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2
Intelligent Systems in Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, Java/C++ and R/Ma advanced programming skills 	tlab		
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge Skills	planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The student 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 requirements.			
Personal Competence Social Competence	based on actual patient data and evaluate the impleme		ack into their work.	
Autonomy	The students can reflect their knowledge and documen	t the results of their work. They can present the	results in an approp	riate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence Enginee	ring: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical Technol	ogy: Elective Compulsory		
	Computational Science and Engineering: Specialisatio	n Systems Engineering and Robotics: Elective	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and R	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective Compu	Isory	
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management a	and Business Administration: Elective Compulse	ory	
	Theoretical Mechanical Engineering: Specialisation Bio	o- and Medical Technology: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory		

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



Course L0334: Intelligent Systems in Medicine		
Тур	Project Seminar	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	
Course L0333: Intelligent Systems	s in Medicine	
Тур	Recitation Section (small)	
Llue fools		

Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Courses				
Title		Тур	Hrs/wk	CP
ntelligent Autonomous Agents and Cogr	itive Robotics (L0341)	Lecture	2	4
ntelligent Autonomous Agents and Cogr	itive 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 rea	ched the following learning results		
Professional Competence				
Skills	decision problems and algorithms for solving the Bayesian networks can be employed as a know can define decision making procedures in simple context, students can describe techniques for measuring the value of information. Students techniques for achieving desired states. Studed different types of equilibria, social choice function Students can select an appropriate agent arch derive decision trees and apply basic optimizat networks and apply bayesian reasoning for sim scenarios. For simple and complex decision ma	atures of environments. The notion of adversarial ag nese problems. For dealing with uncertainty in real- vledge representation and reasoning formalism in sta- ole and sequential settings, with and with complete r solving (partially observable) Markov decision p can identify techniques for simultaneous localizat ents can explain coordination problems and decisi- ons, voting protocol, and mechanism design technique nitecture for concrete agent application scenarios. tion techniques. For those applications they can also apple queries. Students can also name and apply diffi- king students can compute the best action or policie: erent equilibria states,e.g., Nash equilibria. For mu- tain the results.	world scenarios, stude atic and dynamic setti access to the state o roblems, and they c ion and mapping, ar on making in a multi es. For simplified agent o create Bayesian net erent sampling technis of concorete settings	ents can summarize h ngs. In addition, stude f the environment. In t an recall techniques nd can explain plann -agent setting in term application students of works/dynamic Bayes ques for simplified ag . In multi-agent situatio
Personal Competence	Studente are able to discuse their colutions to p	rablama with others. They communicate in English		
oociai oonipelence		roblems with others. They communicate in English		
Autonomy	Students are able of checking their understandi	ng of complex concepts by solving varaints of concre	te problems	
Workload in Hours	Independent Study Time 124, Study Time in Lea	cture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence E	Engineering: Elective Compulsory		
Curricula	Computational Science and Engineering: Speci	alisation Systems Engineering and Robotics: Electiv	e Compulsory	
	0	sation Production Technology: Elective Compulsory		
		ecialisation II. Information Technology: Elective Com	pulsory	
	Mechatronics: Technical Complementary Cours	e: Elective Compulsory		
	• • •	I Organs and Regenerative Medicine: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Implant	• • •		



Course L0341: Intelligent Autonom	nous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainy: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations 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 Came theory (Golden Balls: Split or Share) Decision hereitia gents, Nash equilibrium, Bayes-Nash equilibrium Social Choice Voing protocols, preferences, paradoxes, Arrow's Theorem, Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-profness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness

Course L0512: Intelligent Autonomous Agents and Cognitive Robotics		
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	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 M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of	f Implants (L1588)	Lecture	2	3
Experimental Methods for the Character	zation of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Curricula	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective Compulsory		

Course L1663: Nature's Hierarchie	cal 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



Тур	Lecture
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	
Lecturer	Prof. Christian Schuster
Language	
Cycle	
Content	
Content	Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful f
	engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior
	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
1.14	Ziele Devenie III - Efernie - Enil 4. Onie - en (4000)
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 Sobush W Kürzer "Elektromagnetische Verträglichkeit" Seringer (2007)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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



Course L1588: Development and I	Regulatory Approval of Implants	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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 Meth	ods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Patrick Huber
Language	DE/EN
Cycle	SoSe
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	s in Biomechanics
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	90 Minuten
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 Biomedic	al Engineering
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Courses 1120, Six Simme	
Course L1130: Six Sigma	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008



Course L0001: Fluid Mechanics 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	
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.
	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-Verlag, Berlin, Heidelberg, 2006.
	 Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	 How, H.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 Fachverlag GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW
	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. Springer-Verlag, Berli 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 L0379: Ceramics Technolo	ogy
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	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



Module M1334: BIO II: Bio	materials			
Courses				
Title		Tue	Hrs/wk	CP
Biomaterials (L0593)		Typ Lecture	2	3
	Prof. Michael Morlock	Lootaro	L	0
Admission Requirements				
Recommended Previous	TNOTE			
Knowledge				
Ŭ	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence	, nor taking part bebobblenit, babbine nate reaction are ten	ing rouning roomo		
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisation II	Process Engineering and Biotech	nology: Elective Compulso	ry
Curricula	Materials Science: Specialisation Nano and Hybrid Materials	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopr	ostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Technical Complement			
	Theoretical Mechanical Engineering: Specialisation Bio- and	Medical Technology: Elective Cor	npulsory	



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Hrsivk 2 CP 3 Workload in Hours 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
CP 3 Workload in Hours 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, lesting 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
Workload in Hours 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
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
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
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 Introduction (Importance, nomenclature, relations) Biological materials Basics (components, testing methods) Bone (composition, development, properties, influencing factors) Cartilage (composition, development, structure, properties, influencing factors) Fluids (blood, synovial fluid) Biological structures Menisci of the knee joint Intervertebral discs Teeth
 Biological materials Basics (components, testing methods) Bone (composition, development, properties, influencing factors) Cartilage (composition, development, structure, properties, influencing factors) Fluids (blood, synovial fluid) Biological structures Menisci of the knee joint Intervertebral discs Teeth
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 3.1 Menisci of the knee joint 3.2 Intervertebral discs 3.3 Teeth
3.2 Intervertebral discs 3.3 Teeth
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
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 M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)		Lecture	2	3
Experimental Methods for the Character	zation of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Curricula	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			- con/	

Course L1663: Nature's Hierarchie	cal Materials		
Тур	Seminar		
Hrs/wk			
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		



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 scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful t engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal analysis of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of antennas 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	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Course 11500, Development and I				
Course L1588: Development and Regulatory Approval of Implants				
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	lausur			
Examination duration and scale	10 Minuten			
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 Meth	ods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Patrick Huber
Language	DE/EN
Cycle	SoSe
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	s in Biomechanics		
Тур	Seminar		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale	90 Minuten		
Lecturer	Prof. 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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)	
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 scale	90 Minuten
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008



Тур	Lecture		
Hrs/wk	2		
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	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	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.		
	 Brauer, H.; Mewes, D.: Stoffaustausch einschlie ßlich 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-Verlag, Berlin, Heidelberg, 2006. 		
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.		
	 Fox, How, et al., introduction to Find meetinger. Strong a Cons, 1994. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verla 		
	Berlin, Heidelberg, New York, 2006.		
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag 		
	GmbH, Wiesbaden, 2008.		
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007		
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GV		
	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. Springer-Verlag, Berl 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 L0379: Ceramics Technol	ogy			
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 scale	90 Minuten			
Lecturer	Dr. Rolf Janßen			
Language	DE/EN			
Cycle	WiSe			
Content	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder-based processin e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass and cement science as well a new developments in powderless forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed 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			



Module M0746: Microsyst	em Engineering				
Courses					
Title		Тур	Hrs/wk	CP	
Vicrosystem Engineering (L0680)		Lecture	2	4	
Microsystem Engineering (L0682)		Problem-based Learning	1	1	
Vicrosystem Engineering (L0681)		Recitation Section (small)	1	1	
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	None				
Recommended Previous	Basic courses in physics, mathematics and electron	ric engineering			
Knowledge					
Educational Objectives	After taking part successfully, students have reac	ched the following learning results			
Professional Competence					
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.				
Skills	Students are able to analyze and describe the fu	nctional behaviour of MEMS components and to evalu	uate the potential of r	nicrosystems.	
Personal Competence					
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.				
Autonomy	Students are able to acquire particular knowledg	e using specialized literature and to integrate and ass	sociate this knowledg	e with other fields.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Written exam				
Examination duration and scale	2h				
Assignment for the Following	Electrical Engineering: Core qualification: Comp	ulsory			
Curricula	Computational Science and Engineering: Specia	alisation Systems Engineering and Robotics: Elective	Compulsory		
	International Management and Engineering: Spe	ecialisation II. Electrical Engineering: Elective Compul	sory		
	International Management and Engineering: Spe	ecialisation II. Mechatronics: Elective Compulsory			
	Mechanical Engineering and Management: Spec	cialisation Mechatronics: 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 Manage	ment and Business Administration: Elective Compulse	ory		
	Microelectronics and Microsystems: Core qualific	cation: Elective Compulsory			



Course L0680: Microsystem Engir	
	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Manfred Kasper
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	Problem-based Learning	
Hrs/wk	1	
CP	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Manfred Kasper	
Language	EN	
Cycle	WiSe	
Content	Examples of MEMS components	
	Layout consideration Electric, thermal and mechanical behaviour	
	Design aspects	
Literature	Wird in der Veranstaltung bekannt gegeben	

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



Module M0751: Vibration	Theory			
	Theory			
Courses				
Title		Тур	Hrs/wk	CP
Vibration Theory (L0701)		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 followi	ng learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration The	eory and develop them further.		
Skills	Students are able to denote methods of Vibration Theory and de	evelop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vib	ration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory			
Curricula	Computational Science and Engineering: Specialisation Scienti	fic Computing: Elective Compu	Isory	
	International Management and Engineering: Specialisation II. M	echatronics: Elective Compulso	ory	
	Biomedical Engineering: Specialisation Artificial Organs and Re	generative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopros	theses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology an	d Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Busin	ess Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Core qualification	ion: Compulsory		
	Naval Architecture and Ocean Engineering: Core qualification:	Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification: Elective	e Compulsory		
	Theoretical Mechanical Engineering: Technical Complementary	Course: Elective Compulsory		

Course L0701: Vibration Theory	
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	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	CP	
Microsystems Technology (L0724) Microsystems Technology (L0725)		Lecture	2	4	
	Durf Har White a Trian	Problem-based Learning	2	2	
Module Responsible	Prof. Hoc Khiem Trieu				
Admission Requirements	None				
Recommended Previous Knowledge	Basics in physics, chemistry, mechanics and semiconductor technol	ogy			
Educational Objectives	After taking part successfully, students have reached the following le	orning results			
	Aller laking part successiony, students have reached the following re	anning results			
Professional Competence	Students are able				
Knowledge					
	 to present and to explain current fabrication techniques for mi 	crostructures and especially mether	nods for the fabrication	on of microsensors a	
	microactuators, as well as the integration thereof in more complex s	ystems			
	 to explain in details operation principles of microsensors and microsensors 	croactuators and			
	 to discuss the potential and limitation of microsystems in application 	tion.			
Skills	Students are capable				
	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 prepare and perform their lab experiments in te	am work as well as to present and	I discuss the results in	n front of audience.	
Autonomy	None				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics and Microsys		ulsony		
Assignment for the Pollowing Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsys Electrical Engineering: Specialisation Medical Technology: Elective		uisoly		
Guincula	Computational Science and Engineering: Specialisation Systems En		Compulsorv		
	International Management and Engineering: Specialisation Oysterns El				
	Biomedical Engineering: Specialisation Artificial Organs and Regen		lsory		
	Biomedical Engineering: Specialisation Implants and Endoprosthes		,		
	Biomedical Engineering: Specialisation Medical Technology and Co		y		
	Biomedical Engineering: Specialisation Management and Business				
	Microelectronics and Microsystems: Core qualification: Elective Con				



Course L0724: Microsystems Tech	inology
Тур	Lecture
Hrs/wk	2
CP	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 Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD
	LPCVD, PECVD and LECVD; screen printing) Etabling and Pull Micromorphising (definitions, use chamical stabling, instrantic stabling, instrantic stabling, and stabling, encoderable stabling, instrantic stabling, instran
	Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching, with KOH/TMAH, theory, correct undergutting, measured for companyation and other tophologues; plagma processes, dry othering, base
	with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: bac sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching)
	 Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origan
	microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping)
	 Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors
	thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry
	radiometry, IR sensor: thermopile and bolometer)
	Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive
	capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and
	fabrication process)
	• Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magnet
	resistance, AMR and GMR, fluxgate magnetometer)
	Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organi
	semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip)
	 Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics)
	 MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal corr 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 chi
	bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micr 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 Tec	course L0725: Microsystems Technology	
Тур	Problem-based Learning	
Hrs/wk	2	
CP	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					
itle		Тур	Hrs/w		
echnology Management (L0849)		Problem-based Lea	-	3	
echnology Management Seminar (L085		Problem-based Lea	arning 2	3	
· · ·	Prof. Cornelius Herstatt				
	None				
	Bachelor knowledge in business management				
Knowledge	<u> </u>				
Educational Objectives	After taking part successfully, students have reach	hed the following learning results			
Professional Competence					
Knowledge	Students will gain deep insights into:				
	 Technology Timing Strategies 				
	 Technology Strategies and Lifecyc 	cle Management (I/II)			
	 Technology Intelligence and Plan 				
	 Technology Portfolio Management 	0			
	 Technology Portfolio Methodology 	4			
	 Technology Acquisition and Explo 				
	 IP Management 				
	Organizing Technology Development				
	 Technology Organization & Manager 	gement			
	 Technology Funding & Controlling 				
	L				
Skills	The course aims to:				
Personal Competence Social Competence	 Equip students with an understanding of process-related aspects) Foster a strategic orientation to problem-scorporate strategy Clarify activities of Technology Manageme Strengthen essential communication ski Technology-, Innovation- and R&D-manage Basic concepts, models and tools, relevar Innovation as a process (steps, activities at a process (steps) activities at a process (steps). 	solving within the innovation process as w lent (e.g. technology sourcing, maintenanc ills and a basic understanding of mana gement. Further topics to be discussed inc nt to the management of technology, R&D	well as Technology Mana ce and exploitation) Igerial, organizational an clude:	agement and its importanc	
	Raise awareness for globabl issues				
	····· · · · · · · · · · · · · · · · ·				
Autonomy	 Gain access to knowledge sources 				
	Interpret complicated cases				
	Develop presentation skills				
Workload in Hours	lada and the transition of the Study Transition Last				
	Independent Study Time 110, Study Time in Lect	ure 70			
	6 Written even				
	Written exam				
	90 minutes				
	Global Innovation Management: Core qualification				
Assignment for the Following		versusation L Electives Management: Elect	live Compulsory		
Assignment for the Following	International Management and Engineering: Spe				
Assignment for the Following	Mechanical Engineering and Management: Spec	cialisation Management: Elective Compuls			
Assignment for the Following	Mechanical Engineering and Management: Spec Biomedical Engineering: Specialisation Artificial	cialisation Management: Elective Compuls Organs and Regenerative Medicine: Elect	tive Compulsory		
Assignment for the Following	Mechanical Engineering and Management: Spec	cialisation Management: Elective Compuls Organs and Regenerative Medicine: Elect and Endoprostheses: Elective Compulsor	tive Compulsory ry		



Course L0849: Technology Manag	ement
Тур	Problem-based Learning
Hrs/wk	3
CP	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 Management Seminar		
Тур	Problem-based Learning	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Cornelius Herstatt	
Language	EN	
Cycle	WiSe	
Content	Aspects of and Cases in combination with the content of the lecture.	
Literature	see lecture Technology Management.	



Iodule M0846: Control S	ystems Theory and Design				
courses					
itle		Тур	Hrs/wk	CP	
ontrol Systems Theory and Design (I	0656)	Lecture	2	4	
ontrol Systems Theory and Design (I	0657)	Recitation Section (small)	2	2	
Module Responsible	Prof. Herbert Werner				
Admission Requirements					
Recommended Previous					
Knowledge	-				
Educational Objectives		ng learning results			
Professional Competence					
Knowledg: Skill:	 Students can explain how linear dynamic systems are r states or external excitation as trajectories in state space. They can explain the system properties controllability respectively They can explain the significance of a minimal realisatio. They can explain observer-based state feedback and ho They can explain do f the above to multi-input multi-output. They can explain the z-transform and its relationship wit. They can explain state space models and transfer functi. They can explain the experimental identification of ARX solving a normal equation. They can explain how a state space model can be considered. 	and observability, and their relations n w it can be used to achieve tracking ar out systems n the Laplace Transform on models of discrete-time systems models of dynamic systems, and how ructed from a discrete-time impulse res e space models and vice versa nstruct minimal realisations ous-time and discrete-time domain, an	hip to state feedbac nd disturbance reject the identification pro sponse	k and state estimatio	
Personal Competence Social Competence Autonom	Students can work in small groups on specific problems to arriv	e at joint solutions. notes, software documentation, experi			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Examination	Written exam				
Examination duration and scale	120 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Ele	ctive Compulsory			
Curricula	Electrical Engineering: Core qualification: Compulsory				
	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory				
	Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
	International Management and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
	International Management and Engineering: Specialisation II. I				
	Mechanical Engineering and Management: Specialisation Mec				
	Mechatronics: Core qualification: Compulsory	au onico. Liective Compuisory			
		agenerative Medicino: Elective Commu	son		
	Biomedical Engineering: Specialisation Artificial Organs and Re		sury		
	Biomedical Engineering: Specialisation Implants and Endopros				
	Biomedical Engineering: Specialisation Medical Technology an				
			лу		
	Biomedical Engineering: Specialisation Management and Busin Product Development, Materials and Production: Core qualifica Theoretical Mechanical Engineering: Core qualification: Compu	tion: Elective Compulsory	ory		



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

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



Module M0867: Productio	n Planning & Control and Digital Ent	erprise			
Courses					
Title		Тур	Hrs/wk	CP	
The Digital Enterprise (L0932)		Lecture	2	2	
Production Planning and Control (L0929))	Lecture	2	2	
Production Planning and Control (L0930))	Recitation Section (small)	1	1	
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1	
Module Responsible	Prof. Hermann Lödding				
Admission Requirements	None				
Recommended Previous	Fundamentals of Production and Quality Manage	ment			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	Students can explain the contents of the module i	n 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					
Examination	Written exam				
Examination duration and scale	180 Minuten				
Assignment for the Following	International Management and Engineering: Spec	cialisation II. Product Development and Production: I	Elective Compulsory		
Curricula	Logistics, Infrastructure and Mobility: Specialisation	on Production and Logistics: 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 Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory				
Product Development, Materials and Production: Specialisation Production: Compulsory					
	Product Development, Materials and Production:	duct Development, Materials and Production: Specialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory				
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory			

Course L0932: The Digital Enterpr	ise
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 Plannin	as and Control		
Тур	re		
Hrs/wk	2		
CP	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 Digital Enterprise		
Тур	Recitation Section (small)	
Hrs/wk	1	
CP	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 Applicatio	ns (L0696)	Lecture	2	3		
Electronic Circuits for Medical Applicatio		Recitation Section (small)	1	2		
Electronic Circuits for Medical Applicatio		Laboratory Course	1	1		
Module Responsible	NN					
Admission Requirements	None					
Recommended Previous	Fundamentals of electrical engineering					
Knowledge						
Educational Objectives	After taking part successfully, students have reached the	e following learning results				
Professional Competence		· ·				
Knowledge						
Ŭ	 Students can explain the basic functionality of the 	e information transfer by the central nervous s	ystem			
	 Students are able to explain the build-up of an ad 	ction potential and its propagation along an a	kon			
	 Students can exemplify the communication betw 					
	 Students can describe the special features of low 					
	 Students can explain the functions of prostheses 					
	 Students are able to discuss the potential and lin 	nitations of cochlea implants and artificial eyes	5			
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. 						
	 Students can define the building blocks of electronic 	onic systems for an articilial eye.				
Personal Competence						
Social Competence	 Students are trained to solve problems in the field of medical electronics in teams together with experts with different pr background. 			h different profession		
		idents are able to recognize their specific limitations, so that they can ask for assistance to the right time. Idents can document their work in a clear manner and communicate their results in a way that others can be involved wheneve cessary				
Autonomy	Students can break down their work in appropriaStudents can handle the complex data structures	tudents are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. tudents can break down their work in appropriate work packages and schedule their work in a realistic way. tudents can handle the complex data structures of bioelectrical experiments without needing support. tudents are able to act in a responsible manner in all cases and situations of experimental work.		ecessary.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56					
Credit points						
Examination	Oral exam					
Examination duration and scale	40 min					
Assignment for the Following	Electrical Engineering: Specialisation Medical Technolo	gy: Elective Compulsory				
Curricula	Biomedical Engineering: Specialisation Artificial Organs		Ilsory			
	Biomedical Engineering: Specialisation Implants and Er	ndoprostheses: Elective Compulsory	-			
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory					
	Biomedical Engineering: Specialisation Management ar	nd Business Administration: Elective Compuls	ory			
	Microelectronics and Microsystems: Specialisation Micro					



Course L0696: Electronic Circuits					
Hrs/wk	2				
CP	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer					
0 0	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 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	NN	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only					
Hrs/wk 1 CP 1 Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN Language EN Cycle WiSe Content • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • 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 • 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, 2005 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only	Course L1408: Electronic Circuits	for Medical Applications			
CP 1 Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN 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, 2005 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only	Тур	Laboratory Course			
Workload in Hours Independent Study Time 16, Study Time in Lecture 14 Lecturer NN 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, 2005 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only	Hrs/wk	1			
Lecturer NN 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, 2005 Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor) Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only	CP	1			
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	Workload in Hours	ent Study Time 16, Study Time in Lecture 14			
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	Lecturer	NN			
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 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	Language	EN			
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Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm		 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 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			



Module M1150: Continuur	m Mechanics				
Courses					
Title		Тур	Hrs/wk	СР	
Continuum Mechanics (L1533)		Lecture	2	3	
Continuum Mechanics Exercise (L1534))	Recitation Section (small)	2	3	
Module Responsible	Prof. Swantje Bargmann				
Admission Requirements	None				
Recommended Previous	Mechanics I				
Knowledge	Mechanics II				
Educational Objectives	After taking part successfully, students have reached th	e following learning results			
Professional Competence					
Knowledge					
	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.				
	The students can set up balance laws and apply basics	of deformation theory to specific aspects, both	in applied contexts a	as in research contexts.	
Personal Competence					
Social Competence	The students are able to present solutions to specialists	and to develop ideas further.			
Autonomy	The students are able to assess their own strengths a continuum mechanics on their own.	and weaknesses and to define tasks themselv	es. They can solve	exercises in the area o	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following		n Scientific Computing: Elective Compulsory			
Curricula					
	Mechanical Engineering and Management: Specialisat	ion Materials: Elective Compulsory			
	Mechatronics: Technical Complementary Course: Elect	ive Compulsory			
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective Compu	lsory		
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technology	ology and Control Theory: Elective Compulsory	/		
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective Compulse	ory		
	Product Development, Materials and Production: Core of	qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory			

Course L1533: Continuum Mechan	nics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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



ourse L1534: Continuum Mechanics Exercise			
	Recitation Section (small)		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Swantje Bargmann		
Language	DE/EN		
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: Material M	odeling				
Courses					
Title		Тур	Hrs/wk	СР	
Material Modeling (L1535)		Lecture	2	3	
Material Modeling (L1536)		Recitation Section (small)	2	3	
Module Responsible	Prof. Swantje Bargmann				
Admission Requirements	None				
Recommended Previous	mechanics I				
Knowledge	mechanics II				
	continuum mechanics				
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results			
Professional Competence					
Knowledge	The students can explain the fundamentals of multidimensio	nal consitutive material laws			
Skills	The students can implement their own material laws in fir	nite element codes. In particular, the stu	dents can apply thei	r knowledge to variou	
	problems of material science and evaluate the correspondin	g material models.			
Personal Competence					
Social Competence	The students are able to develop solutions, to present them	to specialists and to develop ideas further			
Autonomy	The students are able to assess their own strengths and w continuum mechanics on their own.	reaknesses and to define tasks themselv	ves. They can solve	exercises in the area	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Computational Science and Engineering: Specialisation Sci	entific Computing: Elective Compulsory			
Curricula	Materials Science: Specialisation Modeling: Elective Compu	lsory			
	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective Compu	Ilsory		
	Biomedical Engineering: Specialisation Implants and Endop	rostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Compulsor	У		
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Compuls	sory		
	Product Development, Materials and Production: Core quali	fication: Elective Compulsory			

Course L1535: Material Modeling	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	 D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Course L1536: Material Modeling	
Тур	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Module M1199: Advanced	Eunctional Materials			
Module Miliss. Advanced				
Courses				
Title		Тур	Hrs/wk	CP
Advanced Functional Materials (L1625)		Lecture	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Fundamentals of Materials Science (I and II)			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of advan	ced materials along with their applica	ations in technology, in parti	cular metallic, ceramic
	polymeric, semiconductor, modern composite materials (bi	omaterials) and nanomaterials.		
Skills	The students will be able to select material configurations a	according to the technical needs and	if necessary to design new	materials considering
Chino	architectural principles from the micro- to the macroscale.	-		-
	them to select optimum materials combinations depending	•		
Personal Competence				
Social Competence	The students are able to present solutions to specialists an	d to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and weaknesses. 			
	define tasks independently.			
	Independent Study Time 152, Study Time in Lecture 28			
Credit points Examination	6 Written exam			
Examination duration and scale	90 min			
Curricula	Mechanical Engineering and Management: Specialisation	Materials: Elective Compulsory		
Gurreula	Biomedical Engineering: Specialisation Artificial Organs ar		ompulsory	
	Biomedical Engineering: Specialisation Implants and Endo	•		
	Biomedical Engineering: Specialisation Medical Technolog		oulsory	
	Biomedical Engineering: Specialisation Management and		•	
	Theoretical Mechanical Engineering: Technical Compleme	ntary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materi	als Science: Elective Compulsory		

Course L1625: Advanced Functional Materials			
Тур	Lecture		
Hrs/wk	2		
CP	6		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28		
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller		
Language	DE/EN		
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	Wird in der Veranstaltung bekannt gegeben		



Courses					
ïtle		Тур	Hrs/wk	CP	
ntroduction to Biochemistry and Molecu	ılar 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 have r	reached the following learning results			
Professional Competence					
Knowledge	The students can				
	describe basic biomolecules;	ded in the DNA.			
	 explain how genetic information is co explain the connection between DNA 				
	• explain the connection between DNA	and proteins,			
Skills	The students can				
	 recommendation of melocylay recompleter for the course of a disease. 				
	 recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; 				
	 explain the relevance of these procedures for some diseases 				
Personal Competence					
Social Competence	The students can participate in discussions in	n research and medicine on a technical level.			
Autonomy	The students can develop understanding of t	opics from the course, using technical literature, by	themselves		
hatohomy					
Workload in Hours	Independent Study Time 62, Study Time in Lo	ecture 28			
Credit points	3				
Examination	Written exam				
Examination duration and scale	60 minutes				
Assignment for the Following	General Engineering Science (German prog	ram): Specialisation Mechanical Engineering, Focu	is Biomechanics: Compulso	ory	
Curricula	General Engineering Science (German progr	ram): Specialisation Biomedical Engineering: Comp	pulsory		
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory				
	General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
		cial Organs and Regenerative Medicine: Elective C			
		ical Technology and Control Theory: Elective Comp	buisory		
		ants and Endoprostheses: Elective Compulsory			
	Technomathematics: Core qualification: Elec Technomathematics: Specialisation III. Engin				
	reconomamentatics, specialisation III. Endin				

ourse L0386: Introduction to Biochemistry and Molecular Biology			
Тур	Lecture		
Hrs/wk	2		
CP	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	CP	
mplants and Fracture Healing (L0376)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	It is recommended to participate in "Introductio	n into Anatomie" before attending "Implants and	Fracture Healing".		
Knowledge					
Educational Objectives	After taking part successfully, students have re	ached the following learning results			
Professional Competence					
Knowledge	The students can describe the different ways h	ow bones heal, and the requirements for their ex	istence.		
	The students can name different treatments for	the spine and hollow bones under given fracture	e morphologies.		
01:11-					
Skills	The students can determine the forces acting v	vithin the human body under quasi-static situation	ns under specific assumptio	ns.	
Personal Competence					
Social Competence	The students can, in groups, solve basic nume	rical modeling tasks for the calculation of interna	I forces.		
	_				
Autonomy	The students can, in groups, solve basic nume	rical modeling tasks for the calculation of interna	I forces.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following	General Engineering Science (German progra	m): Specialisation Mechanical Engineering, Focu	us Biomechanics: Compulso	ory	
Curricula	General Engineering Science (German progra	m): Specialisation Biomedical Engineering: Com	pulsory		
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: 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 L0376: Implants and Fract	ure Healing
•	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
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	CP
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and M	echanics II (Hydrostatics, Kinematics, Dynamics)		
Knowledge	Mathematics I, II, III (in particular differential equatio	ns)		
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
	The students possess an in-depth knowledge reg	arding the derivation of the finite element meth	od and are able to	give an overview of
, another age	theoretical and methodical basis of the method.			give an evention of
01.11	-			
Skills	The students are capable to handle engineering pro	bblems by formulating suitable finite elements, as	sembling the corresp	onding system matric
	and solving the resulting system of equations.			
Personal Competence				
Social Competence	-			
Autonomy	The students are able to independently solve cha	llenging computational problems and develop o	wn finite element ro	utines. Problems can
	identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following	Civil Engineering: Core qualification: Compulsory			
Curricula	Energy Systems: Core qualification: Elective Compu	Ilsory		
	Aircraft Systems Engineering: Specialisation Aircraft	t Systems: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation Air Tra	nsportation Systems: Elective Compulsory		
	Computational Science and Engineering: Specialis	ation Scientific Computing: Elective Compulsory		
	International Management and Engineering: Specia			
	International Management and Engineering: Specia	lisation II. Product Development and Production:	Elective Compulsory	,
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Manageme			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Artificial Org		uisory	
	Product Development, Materials and Production: Co Technomathematics: Specialisation III. Engineering			
	Technomathematics: Core qualification: Elective Co			



Course L0291: Finite Element Met	ourse L0291: Finite Element Methods		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	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		
Literature	Date, N. e. (2000). Finite Lienente wetroden, opiniger venag, benn		
<u> </u>			

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	



Module M1342: Polymers				
Courses				
				0.5
Title	0000)	Тур	Hrs/wk	CP
Structure and Properties of Polymers (L Processing and design with polymers (L		Lecture	2	3 3
Module Responsible		2501010	-	0
Admission Requirements	None			
Recommended Previous	Basics: chemistry / physics / material science			
Knowledge	Dasies, chemistry / physics / material science			
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
	Students can use the knowledge of plastics a	and define the necessary testing and analysis.		
Ŭ	They can explain the complex relationships s			
		e polymers, including to explain neighboring	contexts (e.g. sustai	nability, environment
o	protection).			
Skills	Students are capable of			
	- using standardized calculation methods in a	a given context to mechanical properties (mod	ulus, strength) to calc	ulate and evaluate th
	different materials.			
	- For mechanical recycling problems selecting	g appropriate solutions and sizing example Stiff	ness, corrosion resist	ance.
Personal Competence				
Social Competence	Students can,			
	- arrive at work results in groups and docume	nt them.		
	- provide appropriate feedback and handle fee	edback on their own performance constructively		
Autonomy	 provide appropriate feedback and handle feedback on their own performance constructively. Students are able to, 			
	access their own strengths and weakness			
	- assess their own strengths and weaknesses			
	- assess their own state of learning in specific	c terms and to define further work steps on this	basis guided by teach	ners.
	- assess possible consequences of their profe	essional activity		
Workload in Hours	Independent Study Time 124, Study Time in Lect			
Credit points				
Examination	Written exam			
Examination duration and scale				
	Materials Science: Specialisation Engineering M	aterials: Elective Compulsory		
• •	Biomedical Engineering: Specialisation Implants			
Curricula		Organs and Regenerative Medicine: Elective Corr	nulsory	
		ment and Business Administration: Elective Comp		
		Technology and Control Theory: Elective Computer	•	
	Product Development, Materials and Production:		- ,	
	Product Development, Materials and Production:			
		Specialisation Product Development: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Specialisat			
		. ,		



Course L0389: Structure and Properties of Polymers		
	Lecture	
Hrs/wk		
CP		
	Independent Study Time 62, Study Time in Lecture 28	
	Dr. 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 and design with polymers		
Тур	ecture	
Hrs/wk	2	
CP	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
Bioelectromagnetics: Principles and App	lications (L0371)	Lecture	3	5
Bioelectromagnetics: Principles and App		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous	Basic principles of physics			
Knowledge				
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge	Students can explain the basic principles, relatio	nships, and methods of bioelectromagnetics,	i.e. the quantificati	ion and application
	electromagnetic fields in biological tissue. They can c	lefine and exemplify the most important physical	phenomena and or	der them correspond
	to wavelength and frequency of the fields. They ca	in give an overview over measurement and n	umerical techniques	for characterization
	electromagnetic fields in practical applications . The	y can give examples for therapeutic and diagr	nostic utilization of e	lectromagnetic fields
	medical technology.			
Skills	Students know how to apply various methods to chara	-	-	
	relate to and make use of the elementary solutions of			
	predict for biological tissue, they can order the effects quantitative way. They are able to develop validation			
	for therapeutic and diagnostic applications and make		evaluate the effects t	of electronnagrietic ne
Personal Competence				
	Students are able to work together on subject related	tasks in small groups. They are able to present t	heir results effectivel	y in English (e.g. du
	small group exercises).			
Autonomy	Students are capable to gather information from subj	ect related, professional publications and relate	that information to th	e context of the lectu
	They are able to make a connection between the	ir knowledge obtained in this lecture with th	e content of other I	lectures (e.g. theory
	electromagnetic fields, fundamentals of electrical	engineering / physics). They can communic	ate problems and	effects in the field
	bioelectromagnetics in English.			
M/ · · · · ·				
	Independent Study Time 110, Study Time in Lecture 7	U		
Credit points Examination	o Oral exam			
Examination duration and scale	30-60 minutes			
Assignment for the Following	Electrical Engineering: Specialisation Microwave Eng	ingering Ontics and Electromagnetic Compatib	ility: Elective Compul	son
Curricula	Electrical Engineering: Specialisation Microwave Eng Electrical Engineering: Specialisation Medical Techno		ing. Lieouve oomput	501 y
Carricula	International Management and Engineering: Specialis		sory	
	Biomedical Engineering: Specialisation Artificial Orga	0 0 1		
	Biomedical Engineering: Specialisation Implants and	•		
	Biomedical Engineering: Specialisation Medical Tech		/	



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	SoSe
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)



Тур	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
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)



Courses				
litle		Тур	Hrs/wk	CP
Artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lecture	28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Spec	ialisation II. Process Engineering and Biotecl	nnology: Elective Compulso	ry
Curricula	Materials Science: Specialisation Nano and Hybri	d Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial C	rgans and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants a	and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical T	echnology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Managem	ent and Business Administration: Elective Co	ompulsory	
	Theoretical Mechanical Engineering: Specialisation	••	mpulsory	
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		

ourse L1306: Artificial Joint Replacement		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
	Prof. Michael Morlock	
Language		
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)	
	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				
litle		Тур	Hrs/wk	CP
Robotics and Navigation in Medicine (LC		Lecture	2	3
Robotics and Navigation in Medicine (LC		Project Seminar	2	2
Robotics and Navigation in Medicine (LC		Recitation Section (small)	I	1
Admission Requirements	Prof. Alexander Schlaefer None			
Recommended Previous				
	• principles of math (algebra, analysis/calc	ulus)		
Knowledge	 principles of programming, e.g., in Java of 	or C++		
	 solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have read	thed the following learning results		
Professional Competence				
Knowledge	The students can explain kinematics and trackin	g systems in clinical contexts and illustrate systems	and their components	s in details. Systems o
		and safety and regulations. Students can assess typ	ical systems regarding	design and limitatio
				-
Skills	The students are able to design and evaluate na	vigation systems and robotic systems for medical ap	plications.	
Personal Competence				
Social Competence	The students discuss the results of other groups,	provide helpful feedback and can incoorporate feed	back into their work.	
Autonomy	The students can reflect their knowledge and do	cument the results of their work. They can present th	e results in an approp	riate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lect	ture 70		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence E	ngineering: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical Te	echnology: Elective Compulsory		
	• • •	alisation Systems Engineering and Robotics: Electiv	e Compulsory	
		ecialisation II. Electrical Engineering: Elective Comp		
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
		Organs and Regenerative Medicine: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Implants	• • •		
		Technology and Control Theory: Elective Compulso	ory	
		ment and Business Administration: Elective Compu		
		Specialisation Product Development: Elective Com	•	
	Product Development, Materials and Production			
	Product Development, Materials and Production			
	Theoretical Mechanical Engineering: Technical			
	Theoretical Mechanical Engineering: Specialisat			

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



Sourse L0338: Robotics and Navigation in Medicine				
Тур	Project Seminar			
Hrs/wk	2			
CP	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Alexander Schlaefer			
Language	EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			
Course L0336: Robotics and Navi	gation in Medicine			
Тур	Recitation Section (small)			

Typ	neciation Section (smail)
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



Module M0634: Introduction	on into Medical Technology and Systems	i		
Courses				
Title		Тур	Hrs/wk	CP
Introduction into Medical Technology an	d Systems (L0342)	Lecture	2	3
Introduction into Medical Technology an	d Systems (L0343)	Project Seminar	2	2
Introduction into Medical Technology and	d Systems (L1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous	principles of math (algebra, analysis/calculus)			
Knowledge	principles of stochastics			
	principles of programming, R/Matlab			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	The students can explain principles of medical technolo	av. including imaging systems, computer aid	ed surgery, and medi	cal information system
	They are able to give an overview of regulatory affairs ar		J	
Skills	The students are able to evaluate systems and medical of	devices in the context of clinical applications.		
Personal Competence				
	The students describe a problem in medical technology	as a project, and define tasks that are solved	in a joint effort.	
Autonomy	The students can reflect their knowledge and document	the results of their work. They can present the	results in an appropr	riate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	General Engineering Science (German program): Speci	alisation Biomedical Engineering: Compulsor	ŷ	
Curricula	General Engineering Science (German program, 7 seme			
	Computer Science: Specialisation Computer and Softwa	re Engineering: Elective Compulsory		
	Electrical Engineering: Core qualification: Elective Comp	pulsory		
	General Engineering Science (English program): Specia	alisation Biomedical Engineering: Compulsor	y	
	General Engineering Science (English program, 7 seme	ster): Specialisation Biomedical Engineering	: Compulsory	
	Computational Science and Engineering: Specialisation			
	Computational Science and Engineering: Specialisation	• • • • •		
	Biomedical Engineering: Specialisation Artificial Organs		Ilsory	
	Biomedical Engineering: Specialisation Implants and En		-	
	Biomedical Engineering: Specialisation Medical Techno		у	
	Biomedical Engineering: Specialisation Management ar			
	Technomathematics: Specialisation III. Engineering Scie		-	

Course L0342: Introduction into 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 into Me	ourse L0343: Introduction into Medical Technology and Systems		
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	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction into Me	edical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
CP	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.



odule M0752: Nonlinear	Dynamics			
Courses				
Title		Тур	Hrs/wk CP	
Nonlinear Dynamics (L0702)		Lecture	4 6	
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence Knowledge Skills	Students are able to reflect existing terms and concepts Students are able to apply existing methods and proce			
Personal Competence	Students are able to apply existing methods and proces	sures of Norminear Dynamics and to dev	elop nover methods and procedures.	
	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks inc	ividually and to identify and follow up no	ovel research tasks by themselves.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
Curricula	Computational Science and Engineering: Specialisatio	n Scientific Computing: Elective Compul	lsory	
	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Compulso	ory	
	Mechanical Engineering and Management: Specialisat	ion Mechatronics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective (Compulsory		
	Mechatronics: Specialisation Intelligent Systems and R	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective (Compulsory	
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Core	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification	: Elective Compulsory		

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



Courses				
Title		Тур	Hrs/wk	СР
Semiconductor Technology (L0722)		Lecture	4	5
Semiconductor Technology (L0723)		Laboratory Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science and semice	onductor 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 technique 	es for Si and GaAs substrates,		
	 to discuss in details the relevant fabrication processe integrated circuits and 	es, process flows and the impact thereof or	n the fabrication of sem	iconductor devices ar
	to present integrated process flows.			
Skills				
	Students are capable			
	 to analyze the impact of process parameters on the process parameters on the process parameters. 	ocessing results,		
	 to select and to evaluate processes and 			
	to develop process flows for the fabrication of semicor	nductor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab experi	ments in team work as well as to present a	nd discuss the results in	n front of audience.
Autonomy	None			
Workload in Hours	Independent Study Time 126, Study Time in Lecture 84			
Credit points	7			
Examination	Oral exam			
Examination duration and scale	30 min			-
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics ar	nd Microsystems Technology: Elective Con	npulsory	
Curricula	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Implants and Eng	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compulse	ory	
	Biomedical Engineering: Specialisation Management and	d Business Administration: Elective Compu	lson	



Course L0722: Semiconductor Tec	shnology
Тур	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, 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) Water 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, kinetics, 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 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: excimer laser light source, immersion lithography and phase shift lithography, electron 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) <
Literature	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: Semiconductor Tee	rse L0723: Semiconductor Technology		
Тур	Laboratory 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: Humanoid	I Robotics			
Courses				
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk	CP 2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				-
Knowledge	 Obviolante con cumpio humanaid set -t- 			
	Students can explain humanoid robots.Students learn to apply basic control concepts for	r different tasks in humanoid rebeties		
	• Sudents learn to apply basic control concepts to	i unerent tasks in numanoid tobolics.		
Skills	 Students acquire knowledge about selected asp 	ects of humanoid robotics based on spe	cified literature	
	 Students dequire interview of the second dep Students generalize developed results and presidents 			
	 Students practice to prepare and give a presenta 			
Personal Competence				
Social Competence	 Students are capable of developing solutions in 	interdisciplinary teams and present then	n	
	They are able to provide appropriate feedback a			
Autonomy	 Students evaluate advantages and drawbacks or 	f different forms of presentation for speci	fic tasks and select the best	solution
	 Students familiarize themselves with a scientification 			
	scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control and Powe	er Systems: Elective Compulsory		-
Curricula	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Implants and Er			
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management and		mpulsory	
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Core qualification:	Elective Compulsory		

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



Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Control Curricula Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Computer Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Mechatronics: Specialisation System Systems and Regenerative Mechatronics					
Interand Nonlinear System Identification (L0660) Lecture Module Responsible Prof. Herbert Werner Admission Requirements None Recommended Previous Knowledge Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes Educational Objectives After taking part successfully, students have reached the following learning reat Knowledge Professional Competence Knowledge Students can explain the general framework of the prediction error me structures They can explain how multilayer perceptron networks are used to mode They can explain how an approximate predictive control scheme can be They can explain how an approximate prediction error method to the exp systems They are capable of implementing a nonlinear predictive control scheme They are capable of applying the prediction error method to the exp systems		Hrs/wk	СР		
Admission Requirements None Recommended Previous Knowledge • Classical control (frequency response, root locus) • State space methods • Discrete-time systems • Linear algebra, singular value decomposition • Basic knowledge about stochastic processes Educational Objectives After taking part successfully, students have reached the following learning result Knowledge Professional Competence Knowledge • Students can explain the general framework of the prediction error me structures • They can explain how multilayer perceptron networks are used to mode • They can explain how an approximate predictive control scheme can be • They can explain the idea of subspace identification and its relation to K Skills Skills • Students are capable of applying the prediction error method to the exp systems • They are capable of applying subspace algorithms to the experimental i • They can do the above using standard software tools (including the Mati • They can do the above using standard software tools (including the Mati • They can do the above using standard software tools (including the Mati • They can able to find required information in sources provided (lecture m problems. Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Credit points 3 Examination Assignment for the Following Curricula Electrical Engineering: Specialisation Control and Power Systems: Elective Compu Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medical Engineering: Specialisation Artificial Organs and Regenerative Medical Engineering: Specialisation Artificia	Lecture	2	3		
Recommended Previous Knowledge Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes Professional Competence Knowledge After taking part successfully, students have reached the following learning rest structures Professional Competence Knowledge Students can explain the general framework of the prediction error me structures They can explain how multilayer perceptron networks are used to mode They can explain how an approximate predictive control scheme can be They can explain how an approximate predictive control scheme can be They can explain how an approximate predictive control scheme can be They can explain how an approximate predictive control scheme can be They can explain the idea of subspace algorithms to the exprinental i They are capable of applying subspace algorithms to the exprimental i They are capable of applying subspace algorithms to the experimental i They can do the above using standard software tools (including the Matt Budents are able to find required information in sources provided (lecture n problems.)					
Knowledge Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes Educational Objectives After taking part successfully, students have reached the following learning resumption of the prediction error method to the prediction error method to the structures Students can explain the general framework of the prediction error method to the explain how an approximate predictive control scheme can be They can explain how an approximate predictive control scheme can be They can explain the idea of subspace identification and its relation to K Skills Students are capable of applying the predictive control scheme can be They are capable of applying subspace algorithms to the experimental i They are capable of applying subspace algorithms to the experimental i They are capable of applying subspace algorithms to the experimental is They are capable of applying subspace algorithms to the experimental is They can do the above using standard software tools (including the Matter Social Competence Social Competence Sudents can work in mixed groups on specific problems to arrive at joint solution with the study Time 62. Study Time in Lecture 28 Credit points 3 Examination duration and scale 30 min Assignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Computer Kertorics: Specialisation Intelligent Systems and Robotics: Elective Computer Kertorics: Specialisation Artificial Organs and Regenerative Methot System St					
 State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes Educational Objectives After taking part successfully, students have reached the following learning reat Professional Competence <i>Knowledge</i> Students can explain the general framework of the prediction error me structures They can explain how multilayer perceptron networks are used to mode They can explain how an approximate predictive control scheme can be They can explain the idea of subspace identification and its relation to K Skills Students are capable of applying the prediction error method to the exp systems They are capable of applying subspace algorithms to the expressional competence Social Competence Students can work in mixed groups on specific problems to arrive at joint solutior Autonomy Students are able to find required information in sources provided (lecture me problems. Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Credit points Oral exam Examination duration and scale Oral exam Kasignment for the Following Electrical Engineering: Specialisation Control and Power Systems: Elective Computer Mechatronics: Specialisation Tystems and Robotics: Elective Computer Mechatronics: Specialisation Artificial Organs and Regenerative Meconservice Specialisation Artificial Organs and Regenerative Meconservice					
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Biomedical Engineering: Specialisation Artificial Organs and Regenerative Med	Compulsory				
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Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective					
Biomedical Engineering: Specialisation Medical Technology and Control Theor					
Biomedical Engineering: Specialisation Management and Business Administra					
Theoretical Mechanical Engineering: Technical Complementary Course: Electiv Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	, ,				

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



Courses				
Title		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658)		Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	Classical control (frequency response, root loc	us)		
Knowledge	State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part successfully, students have reached the	he following learning results		
Professional Competence	And taking part successionly, students have reached i			
Knowledge				
	 Students can explain the significance of the ma 	atrix Riccati equation for the solution of LQ proble	ems.	
	They can explain the duality between optimal s			
		rms are used to represent stability and performan		
	 They can explain how an LGG design problem They can explain how model uncertainty can be 	can be formulated as special case of an H2 des		
	 They can explain how model direction of the small g 			rmance for an uncer
	plant.			
	They understand how analysis and synthesis of	conditions on feedback loops can be represented	l as linear matrix ine	qualities.
Chille				
Skills	Students are capable of designing and tuning	LQG controllers for multivariable plant models.		
	They are capable of representing a H2 or H-in	finity design problem in the form of a generalized	d plant, and of using	standard software to
	for solving it.			
	They are capable of translating time and fre		into constraints or	n closed-loop sensit
	functions, and of carrying out a mixed-sensitivit		aning a mixed abia.	ative vebuet centrelle
	 They are capable of constructing an LFT uncer They are capable of formulating analysis and s 			
	solving them.	synthesis conditions as intear matrix mequalities	(LMI), and of using	
	 They can carry out all of the above using stand 	ard software tools (Matlab robust control toolbox).	
Personal Competence				
Social Competence	Students can work in small groups on specific problem			
Autonomy	Students are able to find required information in sou problems.	irces provided (lecture notes, literature, softwar	e documentation) a	na use it to solve gr
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points		• •		
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engine	ering: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Control and Pov	ver Systems: Elective Compulsory		
	Energy Systems: Core qualification: Elective Compuls	ory		
	Aircraft Systems Engineering: Specialisation Aircraft S	ystems: Elective Compulsory		
	Computational Science and Engineering: Specialisation	on Systems Engineering and Robotics: Elective	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and F			
	Mechatronics: Specialisation System Design: Elective			
	Biomedical Engineering: Specialisation Artificial Orga	-	sory	
	Biomedical Engineering: Specialisation Implants and Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Medical Tech			
	Product Development, Materials and Production: Spec			
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	Theoretical Mechanical Engineering: Technical Comp			



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

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



Courses				
Title		Тур	Hrs/wk	CP
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge	The lecture will introduce into the fascinating	area of medical technology with the engineering	point of view. Fundamenta	als in human physiolo
	will be similarly introduced like knowledge in c	control theory.		
	Internal control loops of the human body wil	I be discussed in the same way like the design	of external closed loop s	vstem to example in t
	anesthesia control.			
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be i			will be illustrated. T
	operation of simple equivalent circuits will be o	discussed.		
Skills	Application of modeling, identification, control	technology in the field of medical technology.		
Personal Competence				
Social Competence	Students can develop solutions to specific pro	blems in small groups and present their results (e	.g. during project week)	
Autonomy	Students are able to find necessary literature	and to set it into the context of the lecture. They	are able to continuously e	valuate their knowled
hatonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledg and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.			
		-,		-
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28		
Credit points	3			
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory		
	Biomedical Engineering: Specialisation Artific	al Organs and Regenerative Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Implan	nts and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Compulsory		
	Biomedical Engineering: Specialisation Mana	gement and Business Administration: Elective Co	mpulsory	

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



urses				
e		Тур	Hrs/wk	СР
rketing (Innovation Marketing / Sales	and Services) (L0862)	Problem-based Learning	5	6
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous				
Knowledge	Module International Business			
	-	istration principles (strategic planning, decision	theory, project mar	nagement, internat
	business)	kating Instruments Markat and Compatitor Strategie	- Decise of Duning F	(aboution)
	Understanding of differences in the market	keting Instruments, Market and Competitor Strategies	s, basics of buying b	senavior)
	Unerstanding the differences beweetn B2B			
	 Understanding of the importance of manag 			
	 Good English proficiency; presentation skil 			
		-		
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of	of		
	Specific characteristics in the marketing of	innovative industrial goods and services		
	 The importance of product-related and independent of the importance of			
		et situation and the future market development		
	 The gathering of information about future c 			
	Concepts and approaches to integrate lead	d users and their needs into product and service dev	elopment processes	5
	Approaches and tools for ensuring custome	er-orientation in the development of new products ar	nd innovative service	es
	Marketing mix elements that take into consi	ideration the specific requirements and challenges of	of innovative product	s and services
	 Pricing methods for new products and serv 	ices		
	 The organization of complex sales forces a 	nd personal selling		
	Communication concepts and instruments	for new products and services		
Skills	Based on the acquired knowledge students will be	e able to:		
	Design and to evaluate decisions regarding	g marketing and innovation strategies		
	 Analyze markets by applying market and te 	echnology portfolios		
	Conduct forecasts and develop compelling	scenarios as a basis for strategic planning		
	 Translate customer needs into concepts, 	prototypes and marketable offers and successful	ly apply advanced	methods for custo
	oriented product and service development			
	 Use adequate methods to foster efficient di 	ffusion of innovative products and services		
	 Choose suitable pricing strategies and con 	nmunication 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				
	The students will be able to			
eesial eempeterise				
	 have fruitful discussions and exchange arg 	uments		
	 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 sr	pecific context and to map this knowledge on other n	ew complex problem	n fields.
	Consider proposed business actions in the			
		···· · · · · · · · · · · · · · · · · ·		
Workload in Hours	Independent Study Time 110, Study Time in Lectur	re 70		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Spec	ialisation I. Electives Management: Elective Compul	sory	
Curricula	Mechanical Engineering and Management: Specia	alisation Management: Elective Compulsory		
	Riomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Elective Compul	sorv	
	Biomedical Engineering: Specialisation Implants a			



Тур	Problem-based Learning
Hrs/wk	5
CP	6
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	
Content	I. Introduction 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. Mapping Techniques Perceptual Maps, Gap Model V. User innovations Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis VI. 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
	XI. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Kotler, P., Keller, K. L. (2006). Marketing Management, 12 th edition, Pearson Prentice Hall, New Jersey
	Bo Edvardsson et. al. (2006) Involving Customers in New Service Development, London
	Joe Tidd & Frank M. Hull (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008



Module M1143: Mechanica	al Design Methodology				
Courses					
Title		Тур	Hrs/wk	СР	
Mechanical Design Methodology (L1523	3)	Lecture	3	4	
Mechanical Design Methodology (L1524	ł)	Recitation Section (small)	1	2	
Module Responsible	Prof. Josef Schlattmann				
Admission Requirements	None				
Recommended Previous					
Knowledge					
Educational Objectives	After taking part successfully, students have r	eached the following learning results			
Professional Competence					
Knowledge	Science-based working on product design considering targeted application of specific product design techniques				
	Skills Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various pr				
Skills					
	design techniques following theoretical aspe-	CIS.			
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56			
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	International Management and Engineering:	Specialisation II. Product Development and Production	: Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory			
	Biomedical Engineering: Specialisation Artific	cial Organs and Regenerative Medicine: Elective Com	oulsory		
	Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective Compuls	ory		
	Biomedical Engineering: Specialisation Mana	agement and Business Administration: Elective Compu	lsory		
	Product Development, Materials and Product	ion: Specialisation Product Development: Elective Con	npulsory		
	Product Development, Materials and Product	ion: Specialisation Production: Elective Compulsory			
	Product Development, Materials and Product	ion: Specialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Special	isation Product Development and Production: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory			

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



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



Courses				
		True	Han hade	CD
ïtle	(10044)	Тур	Hrs/wk	CP
lioprocess Engineering - Fundamentals lioprocess Engineering- Fundamentals		Lecture Recitation Section (large)	2	3
Bioprocess Engineering - Fundamental F		Laboratory Course	2	2
Module Responsible			L.	-
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "fundame	entals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence Knowledge	Students are able to describe the basic concepts o microorganisms, as well as to differentiate differen transport processes in bioreactors can be explain technology and downstream processing in detail.	t types of inhibition. The parameters of stoichiom	etry and rheology c	an be named and m
Skills	After successful completion of this module, students			
	 describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaer them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 			
Personal Competence Social Competence	After completion of this module participants should their own opinions and increase their capacity for te			ability to take positio
Autonomy	After completion of this module participants will be present their results in a plenum.	able to solve a technical problem in a team indepe	endently by organizi	ng their workflow and
Workload in Hours	Independent Study Time 96, Study Time in Lecture	84		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): S	necialisation Process Engineering: Compulsory		
Curricula	General Engineering Science (German program): S		/	
	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory			
	General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory			
	Bioprocess Engineering: Core qualification: Compulsory			
	General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory			
	General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory			
	General Engineering Science (English program, 7 s General Engineering Science (English program, 7 s	, ,		
			Compuisory	
	Biomedical Engineering: Specialisation Artificial Org			
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Medical Ter			
	Biomedical Engineering: Specialisation Manageme		ory	
	Technomathematics: Specialisation III. Engineering			
	Process Engineering: Core qualification: Compulso	IV.		



Course L0841: Bioprocess Engine	ering - 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) Technology of sterilization (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		
CP	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language	DE		
Cycle			
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 Engine	ering - Fundamental Practical Course
Тур	Laboratory Course
Hrs/wk	2
CP	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	CP	
ntroduction to Anatomy (L0384)		Lecture	2	3	
Module Responsible	Prof. Udo Schumacher				
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 basal structures and function	s of internal organs and the musculoske	letal system.		
	The students can describe the basic macroscopy and mi	croscopy of those systems.			
Skillo	The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can expl				
Skills	the relevance of structures and their functions in the con		herit of some common dise	eases, mey can exp	
		lext of widespread diseases.			
Personal Competence					
Social Competence	The students can participate in current discussions in bio	omedical research and medicine on a pr	rofessional level.		
Autonomu	v The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the releva				
Autonomy	knowledge themselves.	e by menselves, can participate in co	inversations on the topic at	nu acquire the relev	
	knowledge tremserves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	General Engineering Science (German program): Speci	alisation Mechanical Engineering, Focu	s Biomechanics: Compulso	iry	
Curricula	General Engineering Science (German program): Speci	alisation Biomedical Engineering: Comp	oulsory		
	General Engineering Science (German program, 7 seme	ester): Specialisation Biomedical Engine	eering: Compulsory		
	General Engineering Science (German program, 7 seme	ester): Specialisation Mechanical Engine	eering, Focus Biomechanic	s: Compulsory	
	Electrical Engineering: Specialisation Medical Technolo	gy: Elective Compulsory			
	General Engineering Science (English program): Specia	lisation Mechanical Engineering, Focus	s Biomechanics: Compulso	ry	
	General Engineering Science (English program): Specia	alisation Biomedical Engineering: Comp	ulsory		
	General Engineering Science (English program, 7 seme	ster): Specialisation Mechanical Engine	eering, Focus Biomechanics	s: Compulsory	
	General Engineering Science (English program, 7 seme	ster): Specialisation Biomedical Engine	ering: Compulsory		
	Mechanical Engineering: Specialisation Biomechanics:				
	Biomedical Engineering: Specialisation Medical Techno				
	Biomedical Engineering: Specialisation Management ar				
	Biomedical Engineering: Specialisation Artificial Organs		ompulsory		
	Biomedical Engineering: Specialisation Implants and Er	doprostheses: Elective Compulsory			
	Technomathematics: Specialisation III. Engineering Scie	E 1 0 1			

Module Manual M. Sc. "Biomedical Engineering"



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			
	week: Cardiovascular System			
	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/Michael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag Stuttgart, 2012			



Courses					
Title		Тур	Hrs/wk	CP	
ntroduction to Radiology and Radiation	Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results			
Professional Competence					
Knowledge	Therapy The students can distinguish different types of currently us	sed equipment with respect to its use in	radiation therapy.		
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).				
	The students can describe the patients' passage from	their initial admittance through to follo	ow-up care.		
	Diagnostics				
	The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sect imaging techniques (CT, MRT, US).				
	The students can explain the diagnostic as well as therap	eutic use of imaging techniques, as we	II as the technical basis for	those techniques.	
	The students can choose the right treatment method depe	ending on the patient's clinical history a	nd needs.		
	The student can explain the influence of technical errors of	on the imaging techniques.			
	The student can draw the right conclusions based on the	images' diagnostic findings or the error	protocol.		
Skills	Therapy				
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.				
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.				
	The students can use the therapeutic principle (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 psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).				
	Diagnostics				
	The students can suggest solutions for repairs of imaging	instrumentation after having done erro	r analyses.		
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, and pathophysiology.				
Personal Competence					
Social Competence	The students can assess the special social situation of tur The students are aware of the special, often fear-dominate them appropriately.			neasures and can me	
Autonomy	The students can apply their new knowledge and skills to	a concrete therapy case.			
	The students can introduce younger students to the clinic				
	The students are able to access anatomical knowledge b relevant knowledge themselves.	by themselves, can participate compete	ently in conversations on th	e topic and acquire t	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale Assignment for the Following	90 minutes General Engineering Science (German program): Specia	lication Mochanical Engineering From	Biomochanica: Computer	n/	
Curricula	General Engineering Science (German program): Specia General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 semes Electrical Engineering: Specialisation Medical Technolog	lisation Biomedical Engineering: Comp ster): Specialisation Biomedical Engine ster): Specialisation Mechanical Engine y: Elective Compulsory	ulsory ering: Compulsory eering, Focus Biomechanic	s: Compulsory	
	General Engineering Science (English program): Special General Engineering Science (English program): Special General Engineering Science (English program, 7 semes General Engineering Science (English program, 7 semes Mechanical Engineering: Specialisation Biomechanics: C	isation Biomedical Engineering: Comp ter): Specialisation Mechanical Engine ter): Specialisation Biomedical Engine compulsory	ulsory ering, Focus Biomechanics ering: Compulsory		
	Biomedical Engineering: Specialisation Medical Technolo Biomedical Engineering: Specialisation Management and				

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 TUHH

Course L0383: Introduction to Rac	liology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE SoSe
	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 f ür 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



Module M1280: MED II: Int	roduction to Physiology			
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 following learning results		
Professional Competence				
Knowledge	The students can			
	 describe the basics of the energy metabolisn 	л.		
		', ields of muscle, heart/circulation, neuro- and s	sensory physiology.	
		, ,		
Skills	The students can describe the effects of basic bodi	ly functions (sensory, transmission and proce	essing of information, dev	velopment of forces a
	vital functions) and relate them to similar technical sy	ystems.		
Personal Competence				
Social Competence	The students can conduct discussions in research a			
	The students can find solutions to problems in the fie	eld of physiology, both analytical and metrolog	jical.	
Autonomy	The students can derive answers to questions arisin	g in the course and other physiological areas,	using technical literature	e, by themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German program): S	pecialisation Mechanical Engineering, Focus	Biomechanics: Compulse	ory
Curricula	General Engineering Science (German program): S	pecialisation Biomedical Engineering: Compu	lsory	
	General Engineering Science (German program, 7 s	emester): Specialisation Biomedical Enginee	ring: Compulsory	
	General Engineering Science (German program, 7 s	semester): Specialisation Mechanical Enginee	ering, Focus Biomechanic	s: Compulsory
	Electrical Engineering: Specialisation Medical Tech			
	General Engineering Science (English program): Sp			ry
	General Engineering Science (English program): Sp			
	General Engineering Science (English program, 7 s			s: Compulsory
	General Engineering Science (English program, 7 s		ring: Compulsory	
	Mechanical Engineering: Specialisation Biomechan		1	
	Biomedical Engineering: Specialisation Medical Teo			
	Biomedical Engineering: Specialisation Management Biomedical Engineering: Specialisation Artificial Org			
	Biomedical Engineering: Specialisation Annicial Org	•	mpulsory	
	Technomathematics: Core qualification: Elective Co			
	Technomathematics: Specialisation III. Engineering			
	Engineering			

Course L0385: Introduction to Physiology		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Roger Zimmermann	
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	CP	
Experimental Methods in Biomechanics	(L0377)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	It is recommended to participate in "Implantate und F	rakturheilung" before attending "Experime	ntelle 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 bo	nes heal, and the requirements for their ex	distence.		
	The students can name different treatments for the s	pine and hollow bones under given fracture	e morphologies.		
	The students can describe different measurement to	abniques for foress and movements, and a	hadde the adaguate technique	o for a given took	
	The students can describe different measurement techniques for forces and movements, and choose the adequate technique for a given task.				
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.				
Deve and Commetance					
Personal Competence Social Competence					
Social Competence	The students can, in groups, solve basic experiment	ai lasks.			
Autonomy	The students can, in groups, solve basic experiment	al tasks.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8			
Credit points	3	5			
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following	General Engineering Science (German program): Sp	occiplication Mochanical Engineering For	us Biomochanics: Compulsor	2/	
Curricula	General Engineering Science (German program): Sp			у	
ourroua		• •		: Compulsory	
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program): Sp	• •		v	
		• •			
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants and				
	Biomedical Engineering: Specialisation Medical Tec		noulsory		
	Biomedical Engineering: Specialisation Managemen				
	Technomathematics: Specialisation III. Engineering				

Course 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		

Module Manual M. Sc. "Biomedical Engineering"



Courses					
Title		Тур	Hrs/wk	CP	
Practical Course Introduction to Cell Cul	ture (L0350)	Laboratory Course	3	3	
Regenerative Medicine (L0347)		Seminar	2	3	
Module Responsible					
Admission Requirements	None				
Recommended Previous	For the "Practical course Introduction to cell culture" particip	ation in lecture "Regenerative medicine"			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the fol	owing learning results			
Professional Competence					
Knowledge			-		
	the tissue cells for different methods of tissue engineering	. They are able to give a basic overvie	w of methods for the c	ultivation of animal an	
	human cells.				
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				
Personal Competence					
Social Competence					
,					
	Students are able to reflect their work orally and discuss it w	ith other students and teachers.			
Autonomy					
	After completion of this module, participants will be able to	solve a technical problem in teams of	annrox 2-4 nersons inc	tenendently including	
	presentation of the results.			sependently moldaling	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points	6				
Examination	Presentation				
Examination duration and scale	Oral presentation + discussion (30 min) + protocol internshi	p			
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: Compulsory			
Curricula	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Compuls	ory		
	Biomedical Engineering: Specialisation Management and B	usinges Administration, Elective Comp			

Course L0350: Practical Course Introduction to Cell Culture				
Тур	Laboratory Course			
Hrs/wk	3			
CP	3			
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42			
Lecturer	Prof. Ralf Pörtner			
Language	DE			
Cycle	SoSe			
Content	Introduction to basic skills for cultivation of mammalian cells			
	compact practical course			
Literature				
	Lindl, T. und Gstraunthaler, G.: Zell- und Gewebekultur. Von den Grundlagen zur Laborbank. Spektrum Akademischer Verlag; 6. Auflage 2008.			

Module Manual M. Sc. "Biomedical Engineering"



Course L0347: Regenerative Medi	
0	
	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE/EN
Cycle	SoSe
Content	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



Courses					
litle		Тур	Hrs/wk	CP	
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 ma	utrix inequalities			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the fol	owing learning results			
Professional Competence					
Knowledge	Students can explain the advantages and shortcomi	nas of the classical gain schoduling appro-	ch		
	 They can explain the representation of nonlinear system 		Juli		
	 They can explain the representation of nonlinear sy- They can explain how stability and performance cor 		as I MI conditions		
	 They can explain how stability and periormance con They can explain how gridding techniques can be u 				
	 They are familiar with polytopic and LFT representa 		-	es associated with ea	
	of these model structures		synthesis teeningut		
	Ctudente con evolein hew grant theoretic concente	are used to represent the communication to	pology of multiogon	t ovotomo	
	 Students can explain how graph theoretic concepts They can explain the convergence properties of first 		pology of multiagen	systems	
		·	Thor I PV agont mo	dole	
	They can explain analysis and synthesis conditions	ion formation control loops involving either i	- IT OF LF V agent mo	1612	
	. Otudente con evalein the state energy very service and	tion of anoticilly investight distributed avai	iama that are diaar	atized economics to	
	Students can explain the state space representation	tion of spatially invariant distributed syst	ems that are discre	stized according to	
	actuator/sensor array				
	They can explain (in outline) the extension of the bo	unded real lemma to such distributed syste	ms and the associat	ed synthesis condition	
	for distributed controllers				
Skills					
	 Students are capable of constructing LPV mode 		nixed-sensitivity des	sign of gain-schedu	
	controllers; they can do this using polytopic, LFT or g				
	 They are able to use standard software tools (Matlal 	robust control toolbox) for these tasks			
	Students are able to design distributed formation	controllers for groups of agents with eithe	r LTI or LPV dynam	ics, using Matlab to	
	provided				
	Students are able to design distributed controllers for	r spatially interconnected systems, using th	e Matlab MD-toolbo:	x	
Personal Competence	e				
Social Competence	Students can work in small groups and arrive at joint results				
Autonomy	Students are able to find required information in sources	provided (lecture notes, literature, software	e documentation) ar	nd use it to solve give	
	problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering	Elective Compulsory			
	Electrical Engineering: Specialisation Control and Power S				
ourrioua	Electrical Engineering: Specialisation Control and Power S				
	• • •				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
	International Management and Engineering: Specialisation Sy	• •			
	Mechatronics: Specialisation System Design: Elective Com				
	Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robol				
	Biomedical Engineering: Specialisation Implants and Endo				
	Biomedical Engineering: Specialisation Artificial Organs and		sorv		
	Biomedical Engineering: Specialisation Annical Organs an Biomedical Engineering: Specialisation Management and E	-			
	Biomedical Engineering: Specialisation Management and Biomedical Engineering: Specialisation Medical Technolog				
	mooroada moonamear Engineering. Oore qualification: Ele	ntary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Ele				



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

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



Module M1227: Lecture T	issue Engineering - Regenerative Medicine			
Courses				
Title		Тур	Hrs/wk	СР
Lecture Tissue Engineering - Regenera	tive Medicine (L1664)	Seminar	2	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	owing learning results		
Professional Competence				
Knowledge	After successful completion of the module students can outline the actual concepts of Tissue Engineering and regenerative medicine and of explain the basic udnerlying principles of the discussed topics.			
Skills	After successful completion of the module students will be regenerative medicine.	able to to analyse and evaluate of	current research topics for Tis	ssue Engineering an
Personal Competence				
Social Competence	Students are able to work together as a team with several students to solve given tasks and discuss their results in the plenary and to defend them			
Autonomy	The students are able to present independently the results of	f their subtasks in a presentation		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6			
Examination	Written elaboration			
Examination duration and scale	written report (10 pages)			
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Compuls	ory	
Curricula	Biomedical Engineering: Specialisation Implants and Endop	rostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Bi	usiness Administration: Elective Co	ompulsory	

Course L1664: Lecture Tissue Eng	gineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, 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



Specialization Management and Business Administration

Module M0623: Intelligent	Systems in Medicine				
Courses					
Title		Тур	Hrs/wk	СР	
Intelligent Systems in Medicine (L0331)		Lecture	2	3	
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2	
Intelligent Systems in Medicine (L0333)		Recitation Section (small)	1	1	
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, Java/C++ and R/Matlab advanced programming skills 				
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results			
Professional Competence					
Knowledge Skills	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, an planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The student 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 requirements. The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the method				
Personal Competence Social Competence	based on actual patient data and evaluate the implemented The students discuss the results of other groups, provide he		ack into their work.		
Autonomy					
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points	6				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering:	Elective Compulsory			
Curricula					
	Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Roboti	ics: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and	d Regenerative Medicine: Elective Comput	lsory		
	Biomedical Engineering: Specialisation Implants and Endop	prostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technology	y and Control Theory: Elective Compulsory	/		
	Biomedical Engineering: Specialisation Management and B				
	Theoretical Mechanical Engineering: Specialisation Bio- an	d Medical Technology: Elective Compulso	ry		
	Theoretical Mechanical Engineering: Technical Complemer	ntary Course: Elective Compulsory			

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



Course L0334: Intelligent Systems in Medicine			
Тур	Project Seminar		
Hrs/wk	2		
CP	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		
Course L0333: Intelligent Systems	s in Medicine		
Тур	Recitation Section (small)		
Hrs/wk	1		
CB	-		

CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Courses				
Title		Тур	Hrs/wk	CP
Intelligent Autonomous Agents and Cogr	itive Robotics (L0341)	Lecture	2	4
Intelligent Autonomous Agents and Cogr	itive 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 reached	the following learning results		
Professional Competence				
Skills	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.			
Personal Competence Social Competence	Students are able to discuss their solutions to proble	ems with others. They communicate in English		
Autonomy	Students are able of checking their understanding o		ete problems	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	50		
Credit points	6 Written even			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engin Computational Science and Engineering: Specialisa		e Compulsory	
Guincula	International Production Management: Specialisatio		compaisory	
	International Management and Engineering: Special	6, 1 ,	npulsory	
	Mechatronics: Technical Complementary Course: E			
	Biomedical Engineering: Specialisation Artificial Org		pulsory	
	Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Teo	chnology and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Manageme			



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

Course L0512: Intelligent Autonomous Agents and Cognitive Robotics	
Тур	Recitation Section (small)
Hrs/wk	2
CP	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 M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of	f Implants (L1588)	Lecture	2	3
Experimental Methods for the Character	zation of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 t	he 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 Following	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Compulso	ry	
	Biomedical Engineering: Specialisation Artificial Orga	ns and Rogonorative Medicine: Elective Comput	- con/	

Course L1663: Nature's Hierarchie	cal 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



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 scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful t engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of antennas parameters - Most important types of antennas parameters - Numerical techniques and cholos 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
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE/EN	
Cycle	SoSe	
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 Method	s in Biomechanics	
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	90 Minuten	
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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Courses 1120, Six Simme		
Course L1130: Six Sigma		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbader 2008	



Course L0001: Fluid Mechanics 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	
	Introduction into Computational Fluid Dynamics	
Literature		
	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.	
	 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 Strömungen. Springer Verlag Berlin, Heidelberg, New York, 2006. 	
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag GmbH, Wiesbaden, 2008. 	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW	
	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. Springer-Verlag, Berli Heidelberg, 2008. 	
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.	
	 van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 	



Course L0379: Ceramics Technol	ogy	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Dr. Rolf Janßen	
Language	DE/EN	
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	



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

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of	f Implants (L1588)	Lecture	2	3
Experimental Methods for the Character	ization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Curricula				
	Biomedical Engineering: Specialisation Medical Tech	inology and Control Theory: Elective Compulsory		

Course L1663: Nature's Hierarchical 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	



Turn	Lecture
,,	
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	
Lecturer	
Language	
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful f engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior 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 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
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Course L1588: Development and Regulatory Approval of Implants		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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 Meth	ods for the Characterization of Materials		
Тур	ecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale	90 min		
Lecturer	Prof. Patrick Huber		
Language	DE/EN		
Cycle	SoSe		
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 Method	s in Biomechanics		
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	90 Minuten		
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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
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 scale	90 Minuten		
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 		
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008		



Course L0001: Fluid Mechanics II		
Тур	Lecture	
Hrs/wk	2	
CP		
Workload in Hours	dependent Study Time 92, Study Time in Lecture 28	
Examination Form	ausur	
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		
	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 Strömungen. Springer Verlag Berlin, Heidelberg, New York, 2006. 	
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag GmbH, Wiesbaden, 2008. 	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW	
	Fachverlage GmbH, Wiesbaden, 2009.	
	 Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. Turkunder de En Elvider oberlingte verlag de Gruyter, Berlin, New York, 2007. 	
	 Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berli 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 L0379: Ceramics Technol	ogy		
Тур	Lecture		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale	90 Minuten		
Lecturer	Dr. Rolf Janßen		
Language	DE/EN		
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 a new developments in powderless forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed i 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		



Module M1334: BIO II: Bio	materials			
Courses				
Title		Тур	Hrs/wk	CP
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisa	ation II. Process Engineering and Biotech	nology: Elective Compulso	ry
Curricula	Materials Science: Specialisation Nano and Hybrid Ma	terials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techn	•••		
	Biomedical Engineering: Specialisation Management a		mpulsory	
	Theoretical Mechanical Engineering: Technical Compl			
	Theoretical Mechanical Engineering: Specialisation Bi	o- and Medical Technology: Elective Com	npulsory	



Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk CP	3	
Workload in Hours	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 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.	



	en Frankreaking			
Nodule M0746: Microsyst	em Engineering			
Courses				
Fitle		Тур	Hrs/wk	CP
Aicrosystem Engineering (L0680)		Lecture	2	4
Microsystem Engineering (L0682)		Problem-based Learning	1	1
Vicrosystem Engineering (L0681)		Recitation Section (small)	1	1
Module Responsible	Prof. Manfred Kasper			
Admission Requirements	None			
Recommended Previous	Basic courses in physics, mathematics and elect	ric engineering		
Knowledge				
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	The students know about the most important tech	nnologies and materials of MEMS as well as their app	lications in sensors a	and actuators.
Skills	Students are able to analyze and describe the fu	inctional behaviour of MEMS components and to evalu	uate the potential of i	microsystems.
Personal Competence				
Social Competence	Students are able to solve specific problems alor	ne or in a group and to present the results accordingly	·.	
,				
Autonomy	Students are able to acquire particular knowledg	ge using specialized literature and to integrate and ass	sociate this knowledg	ge with other fields.
Workload in Hours	Independent Study Time 124, Study Time in Lect	ture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the Following	Electrical Engineering: Core qualification: Comp	ulsory		
Curricula	Computational Science and Engineering: Specia	alisation Systems Engineering and Robotics: Elective	Compulsory	
	International Management and Engineering: Spe	ecialisation II. Electrical Engineering: Elective Compul	sory	
	International Management and Engineering: Spe	ecialisation II. Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Spec	cialisation Mechatronics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Elective Compulse	ory	
	Microelectronics and Microsystems: Core qualified	cation: Elective Compulsory		



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

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

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



Module M0751: Vibration	Theony			
	Theory			
Courses				
Title		Тур	Hrs/wk	CP
Vibration Theory (L0701)		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 followi	ng learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration The	eory and develop them further.		
Skills	Students are able to denote methods of Vibration Theory and de	evelop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vib	ration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory			
Curricula	Computational Science and Engineering: Specialisation Scient	fic Computing: Elective Compute	sory	
	International Management and Engineering: Specialisation II. N	echatronics: Elective Compulso	iry	
	Biomedical Engineering: Specialisation Artificial Organs and Re	generative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopros			
	Biomedical Engineering: Specialisation Medical Technology an			
	Biomedical Engineering: Specialisation Management and Busin		mpulsory	
	Product Development, Materials and Production: Core qualifica			
	Naval Architecture and Ocean Engineering: Core qualification:			
	Theoretical Mechanical Engineering: Core qualification: Elective			
	Theoretical Mechanical Engineering: Technical Complementary	Course: Elective Compulsory		

Course L0701: Vibration Theory	
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	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		Тур	Hrs/wk	CP	
Microsystems Technology (L0724)		Lecture	2	4	
Microsystems Technology (L0725)		Problem-based Learning	2	2	
Module Responsible	Prof. Hoc Khiem Trieu				
Admission Requirements	None				
Recommended Previous	Basics in physics, chemistry, mechanics and semiconductor	technology			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the fol	owing learning results			
Professional Competence					
Knowledge	Students are able				
	to present and to combine correct febrication to shaking	a for microstructures and consciently motion	ada far tha fabricati	n of microsonoore	
	 to present and to explain current fabrication technique 		lous for the labricatio	In or microsensors a	
	microactuators, as well as the integration thereof in more co	mplex systems			
	• to explain in details operation principles of microsensors	and microactuators and			
	 to discuss the potential and limitation of microsystems in 	application.			
01.11					
Skills	Students are capable				
	to analyze the feasibility of microsystems,				
	to develop process flows for the fabrication of microstructures and				
	 to apply them. 				
Personal Competence					
Social Competence					
Social Competence					
	Students are able to prepare and perform their lab experime	ents in team work as well as to present and	discuss the results in	front of audience.	
Autonomy	None				
	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics and	Microsystems Technology: Elective Comp	ulsory		
Curricula	Electrical Engineering: Specialisation Medical Technology:	Elective Compulsory			
	Computational Science and Engineering: Specialisation Sy	stems Engineering and Robotics: Elective	Compulsory		
	International Management and Engineering: Specialisation	II. Mechatronics: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and	d Regenerative Medicine: Elective Compu	lsory		
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technolog	and Control Theory: Elective Compulsor	/		
	Biomedical Engineering: Specialisation Management and E	usiness Administration: Elective Compuls	ory		
	Microelectronics and Microsystems: Core qualification: Elec	tive Compulsory			



Course L0724: Microsystems Tec	hnology
Тур	Lecture
Hrs/wk	2
CP	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: magnetor resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Acluato
	 optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filterinkjet 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 conregeneration) 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 chi 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 Tec	ourse L0725: Microsystems Technology	
Тур	Problem-based Learning	
Hrs/wk	2	
CP	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					
litle		Тур	Hrs/wk	СР	
inite Element Methods (L0291)		Lecture	2	3	
inite Element Methods (L0804)		Recitation Section (large)	2	3	
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and	Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge	Mathematics I, II, III (in particular differential equa	ions)			
Educational Objectives	After taking part successfully, students have reac	ned the following learning results			
Professional Competence					
	The students possess an in-depth knowledge i	egarding the derivation of the finite element metho	nd and are able to o	nive an overview of t	
Nilowieuge	theoretical and methodical basis of the method.	equilities and a conversion of the limite element metric			
Skille	The students are capable to bandle orgineering	problems by formulating suitable finite elements, ass	ombling the corresp	anding system matric	
Skills	and solving the resulting system of equations.	problems by formulating suitable finite elements, as	sembling the correspo	shung system matric	
	and solving the resulting system of equations.				
Personal Competence					
Social Competence	-				
Autonomy	The students are able to independently solve c	nallenging computational problems and develop ov	vn finite element rou	tines. Problems can	
	identified and the results are critically scrutinized				
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56			
Credit points	6				
Examination	Written exam				
Examination duration and scale	120 min				
Assignment for the Following	Civil Engineering: Core qualification: Compulsor	,			
Curricula	Energy Systems: Core qualification: Elective Con	pulsory			
	Aircraft Systems Engineering: Specialisation Airc	raft Systems: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Air	ransportation Systems: Elective Compulsory			
	Computational Science and Engineering: Specia	lisation Scientific Computing: Elective Compulsory			
	International Management and Engineering: Spe				
		cialisation II. Product Development and Production: I	Elective Compulsory		
	Mechatronics: Core qualification: Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory				
		nent and Business Administration: Elective Compuls			
		Fechnology and Control Theory: Elective Compulsor			
		Organs and Regenerative Medicine: Elective Compu	isory		
	Product Development, Materials and Production: Technomathematics: Specialisation III. Engineeri				
	recimoniamentatics. Specialisation III. Engineen	ig ocience. Liective compuisory			
	Technomathematics: Core gualification: Elective	Compulsory			



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

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



Courses					
Title		Тур		Hrs/wk	CP
Technology Management (L0849)		Problem-base	ed Learning	3	3
Technology Management Seminar (L085	50)	Problem-base	-	2	3
	Prof. Cornelius Herstatt		-		
Admission Requirements	None				
Recommended Previous	Bachelor knowledge in business management				
Knowledge					
Educational Objectives	After taking part successfully, students have rea	ached the following learning results			
Professional Competence		~ ~			
	Students will gain deep insights into:				
	Technology Timing Strategies				
	 Technology Strategies and Lifed 	cycle Management (I/II)			
	 Technology Intelligence and Pla 				
	 Technology Portfolio Management 	0			
	 Technology Portfolio Methodolo 	ду			
	 Technology Acquisition and Exp 	ploitation			
	 IP Management 				
	Organizing Technology Development				
	 Technology Organization & Mar 	nagement			
	 Technology Funding & Controlli 	ng			
Skills	The course aims to:				
		Anna (Tacharlan Managara)			
	 Develop an understanding of the impor Equip students with an understanding 				
	process-related aspects)		gy Management	(strategic, operation	nai, organizational a
	 Foster a strategic orientation to problem 	n-solving within the innovation proces	s as well as Tech	nology Managemer	nt and its importance
	corporate strategy	······································			····
	 Clarify activities of Technology Manage 	ment (e.g. technology sourcing, mainte	enance and explo	itation)	
	 Strengthen essential communication s 				ncial issues concern
	Technology-, Innovation- and R&D-mar	nagement. Further topics to be discuss	ed include:		
	Basic concepts, models and tools, relev		R&D and innovat	ion	
	 Innovation as a process (steps, activitie) 	s and results)			
Personal Competence					
Social Competence					
	Interact within a team				
	 Raise awareness for globabl issues 				
Autonomy					
	Gain access to knowledge sources				
	Interpret complicated cases				
	 Develop presentation skills 				
Workload in Hours	Independent Study Time 110, Study Time in Le	ecture 70			
Credit points					
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	Global Innovation Management: Core qualifica				
Curricula	International Management and Engineering: S			sory	
	Mechanical Engineering and Management: Sp				
	Biomedical Engineering: Specialisation Artificia			sory	
	Biomedical Engineering: Specialisation Implan Biomedical Engineering: Specialisation Medica				



Course L0849: Technology Manag	ement
Тур	Problem-based Learning
Hrs/wk	3
CP	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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Manag	ourse L0850: Technology Management Seminar		
Тур	Problem-based Learning		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Cornelius Herstatt		
Language	EN		
Cycle	WiSe		
Content	Aspects of and Cases in combination with the content of the lecture.		
Literature	see lecture Technology Management.		



Module M0846: Control Sy	stems Theory and Design				
Courses					
Title		Тур	Hrs/wk	СР	
Control Systems Theory and Design (LC	656)	Lecture	2	4	
Control Systems Theory and Design (LC	657)	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	ng learning results			
Professional Competence		0 0			
Knowledge Skills	 Students can explain how linear dynamic systems are rastates or external excitation as trajectories in state space. They can explain the system properties controllability respectively They can explain the significance of a minimal realisatio. They can explain observer-based state feedback and how they can explain the z-transform and its relationship with. They can explain the z-transform and its relationship with. They can explain the experimental identification of ARX solving a normal equation. They can explain how a state space model can be constant. Students can transform transfer function models into state. They can design LQG controllers for multivariable plants. They can carry out a controller design both in continu sampling rate. 	and observability, and their relations n w it can be used to achieve tracking a out systems n the Laplace Transform on models of discrete-time systems models of dynamic systems, and how ructed from a discrete-time impulse re e space models and vice versa nstruct minimal realisations ous-time and discrete-time domain, a	ship to state feedbac nd disturbance reject v the identification pro sponse	k and state estimatio	
Personal Competence Social Competence Autonomy	 They can carry out all these tasks using standard software Students can work in small groups on specific problems to arrive Students can obtain information from provided sources (lecture problems. They can assess their knowledge in weekly on-line tests and the 	e at joint solutions. notes, software documentation, expe			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Written exam				
Examination duration and scale	120 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: Ele	ctive Compulsory			
Curricula	Electrical Engineering: Core qualification: Compulsory				
	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: C	ompulsory			
	Computational Science and Engineering: Specialisation System	as Engineering and Robotics: Elective	Compulsory		
	International Management and Engineering: Specialisation II. E	lectrical Engineering: Elective Compu	Isory		
	International Management and Engineering: Specialisation II. M		-		
	Mechanical Engineering and Management: Specialisation Mech				
	Mechatronics: Core qualification: Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Re	denerative Medicine: Elective Compu	Ilsorv		
	Biomedical Engineering: Specialisation Antical Organs and re Biomedical Engineering: Specialisation Implants and Endopros	-			
	Biomedical Engineering: Specialisation Medical Technology an				
			orv		
	Biomedical Engineering: Specialisation Medical Ferniology and Biomedical Engineering: Specialisation Management and Busir Product Development, Materials and Production: Core qualifica	ness Administration: Elective Compuls	ory		



Course L0656: Control Systems T	Course L0656: Control Systems Theory and Design		
Тур	Lecture		
Hrs/wk	2		
CP	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	WiSe		
Content	State space methods (single-input single-output)		
	State space models and transfer functions, state feedback		
	Coordinate basis, similarity transformations		
	Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem		
	Controllability and pole placement		
	State estimation, observability, Kalman decomposition		
	Observer-based state feedback control, reference tracking		
	Transmission zeros		
	Optimal pole placement, symmetric root locus		
	Multi-input multi-output systems		
	Transfer function matrices, state space models of multivariable systems, Gilbert realization		
	Poles and zeros of multivariable systems, minimal realization		
	• Closed-loop stability		
	Pole placement for multivariable systems, LQR design, Kalman filter		
	Digital Control		
	Discrete-time systems: difference equations and z-transform		
	Discrete-time state space models, sampled data systems, poles and zeros		
	* Frequency response of sampled data systems, choice of sampling rate		
	System identification and model order reduction		
	Least squares estimation, ARX models, persistent excitation		
	Identification of state space models, subspace identification		
	Balanced realization and model order reduction		
	Case study		
	Modelling and multivariable control of a process evaporator using Matlab and Simulink		
	Software tools		
	Matlab/Simulink		
Literature			
	Werner, H., Lecture Notes "Control Systems Theory and Design"		
	T. Kailath "Linear Systems", Prentice Hall, 1980		
	K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997		
	L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999		
	1		

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



Module M0867: Productio	n Planning & Control and Digital Ent	erprise		
Courses				
Title		Тур	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929))	Lecture	2	2
Production Planning and Control (L0930))	Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality Manage	ment		
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the module i	n 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 tear	ns and present them to others.		
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lectur	e 84		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following	International Management and Engineering: Spec	cialisation II. Product Development and Production: I	Elective Compulsory	
Curricula	Logistics, Infrastructure and Mobility: Specialisation	on Production and Logistics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial C	Organs and Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical	echnology and Control Theory: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Manager	nent and Business Administration: Compulsory		
	Product Development, Materials and Production:	Specialisation Product Development: Elective Comp	ulsory	
	Product Development, Materials and Production:	Specialisation Production: Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisati	on Product Development and Production: Elective C	ompulsory	
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		

Course L0932: The Digital Enterpr	ise
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 Plannin	a and Control
Тур	Lecture
Hrs/wk	2
CP	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 Plannin	urse 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
CP	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



Module M1150: Continuu	m Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534))	Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	Mechanics I			
Knowledge	Mechanics II			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to c	alculate the mechanical behavior of materials.		
	The students can set up balance laws and apply basics	of deformation theory to specific aspects, both	in applied contexts a	as in research contexts.
Personal Competence				
Social Competence	The students are able to present solutions to specialists	and to develop ideas further.		
Autonomy	The students are able to assess their own strengths a continuum mechanics on their own.	nd weaknesses and to define tasks themselv	es. They can solve o	exercises in the area c
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computational Science and Engineering: Specialisation	n Scientific Computing: Elective Compulsory		
Curricula	Materials Science: Specialisation Modeling: Elective Co	ompulsory		
	Mechanical Engineering and Management: Specialisat	on Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elect			
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	ology and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Elective Compulse	ory	
	Product Development, Materials and Production: Core of	qualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Comple	ementary Course: Elective Compulsory		

Course L1533: Continuum Mechan	nics
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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 Mechanics Exercise	
	Recitation Section (small)
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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



Courses				
Title		Тур	Hrs/wk	СР
Electronic Circuits for Medical Applicatio	ns (L0696)	Typ Lecture	2	3
Electronic Circuits for Medical Applicatio		Recitation Section (small)	1	2
Electronic Circuits for Medical Applicatio		Laboratory Course	1	- 1
Module Responsible				
Admission Requirements	None			
Recommended Previous	Fundamentals of electrical engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge				
	Students can explain the basic functionality	of the information transfer by the central nervous	system	
		an action potential and its propagation along an a	xon	
	Students can exemplify the communication			
		of low-noise amplifiers for medical applications		
	 Students can explain the functions of prosth 			
	 Students are able to discuss the potential ar 	nd limitations of cochlea implants and artificial eye	S	
Skills				
	 Students can calculate the time dependent 			
		ovement of low-noise and low-power signal acqui	sition.	
	Students can develop the block diagrams o			
	 Students can define the building blocks of e 	lectronic systems for an articitial eye.		
Personal Competence				
Social Competence		the field of medical electronics in teams toge	ther with experts wit	th different profession
	 Students are able to recognize their specific 	limitations, so that they can ask for assistance to	bo right time	
		ar manner and communicate their results in a wa	-	involved whenever it
Autonomy	• Chudante era able te realisticallu iudea the e			
		tatus of their knowledge and to define actions for i		5655di y.
		opriate work packages and schedule their work in tures of bioelectrical experiments without needing		
		inner in all cases and situations of experimental w		
		וווופו ווו מו כמצפג מום גונטמניטוג טו פגעפוווופוזמו ש	UIK.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	9 56		
Credit points	6			
Examination	Oral exam 40 min			
Examination duration and scale	-	nelemu Fleetive Computer		
Assignment for the Following	Electrical Engineering: Specialisation Medical Tech		Jaan	
Curricula	Biomedical Engineering: Specialisation Artificial Or		uisory	
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme Microelectronics and Microsystems: Specialisation		sory	



Course L0696: Electronic Circuits	
Тур	Lecture
	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
0 0	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 Circuits	Course 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	NN		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		



Course L1408: Electronic Circuits	for Medical Applications
Тур	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
Language	EN
Cycle	WiSe
Content	
	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 M1151: Material M	odeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	mechanics I			
Knowledge	mechanics II			
	continuum mechanics			
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multidimensio	nal consitutive material laws		
Skills				
	problems of material science and evaluate the correspondin	g material models.		
Personal Competence				
Social Competence	The students are able to develop solutions, to present them	to specialists and to develop ideas further		
Autonomy	The students are able to assess their own strengths and w continuum mechanics on their own.	reaknesses and to define tasks themselv	ves. They can solve	exercises in the area
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computational Science and Engineering: Specialisation Sci	entific Computing: Elective Compulsory		
Curricula	Materials Science: Specialisation Modeling: Elective Compu	lsory		
	Mechanical Engineering and Management: Specialisation N	laterials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective Compu	Ilsory	
	Biomedical Engineering: Specialisation Implants and Endop	rostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Compulsor	У	
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Compuls	sory	
	Product Development, Materials and Production: Core quali	fication: Elective Compulsory		

Course L1535: Material Modeling			
Тур	Lecture		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Swantje Bargmann		
Language	DE/EN		
Cycle	WiSe		
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure 		
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer		



Course L1536: Material Modeling			
Тур	Recitation Section (small)		
Hrs/wk			
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Swantje Bargmann		
Language	DE/EN		
Cycle	WiSe		
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure 		
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer		



Functional Materials			
Functional Materials			
	Тур	Hrs/wk	CP
	Lecture	2	6
Prof. Patrick Huber			
None			
Fundamentals of Materials Science (I and II)			
After taking part successfully, students have reached the	following learning results		
The students will be able to explain the properties of adv	vanced materials along with their applica	tions in technology, in parti	cular metallic, ceramic
polymeric, semiconductor, modern composite materials	(biomaterials) and nanomaterials.		
The students will be able to select material configuration	as according to the technical needs and	if nocossany to design nov	materials considering
	•	lew on modern materials a	science, which enables
The students are able to present solutions to specialists	and to develop ideas further.		
The students are able to			
assess their own strengths and weaknesses.			
define tasks independently.			
Independent Study Time 152, Study Time in Leature 29			
. , . ,			
	on Materials: Elective Compulsory		
		ompulsory	
	•		
		ulsory	
Theoretical Mechanical Engineering: Technical Comple	mentary Course: Elective Compulsory		
Theoretical Mechanical Engineering: Specialisation Mat	erials Science: Elective Compulsory		
	After taking part successfully, students have reached the The students will be able to explain the properties of adv polymeric, semiconductor, modern composite materials The students will be able to select material configuration architectural principles from the micro- to the macrosca them to select optimum materials combinations dependi The students are able to present solutions to specialists The students are able to present solutions to specialists The students are able to • assess their own strengths and weaknesses. • define tasks independently. Independent Study Time 152, Study Time in Lecture 28 6 Written exam 90 min Materials Science: Core qualification: Compulsory Mechanical Engineering and Management: Specialisati Biomedical Engineering: Specialisation Implants and Er Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management ar Theoretical Mechanical Engineering: Technical Comple	Typ Lecture Prof. Patrick Huber None Fundamentals of Materials Science (I and II) After taking part successfully, students have reached the following learning results The students will be able to explain the properties of advanced materials along with their applica polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials. The students will be able to select material configurations according to the technical needs and, architectural principles from the micro- to the macroscale. The students will also gain an overv them to select optimum materials combinations depending on the technical applications. The students are able to present solutions to specialists and to develop ideas further. The students are able to • assess their own strengths and weaknesses. • define tasks independently. Independent Study Time 152, Study Time in Lecture 28 6 Written exam 90 min Materials Science: Core qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Comp	Typ Hrs/wk Lecture 2 Prof. Patrick Huber 2 None

ourse L1625: Advanced Functional Materials		
Тур	cture	
Hrs/wk	2	
CP	6	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller	
Language	DE/EN	
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	Wird in der Veranstaltung bekannt gegeben	



Courses				
ïtle		Тур	Hrs/wk	CP
ntroduction to Biochemistry and Molecu	ılar 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 have	reached the following learning results		
Professional Competence				
Knowledge	The students can			
	 describe basic biomolecules; explain how genetic information is co 	ded in the DNA.		
	explain now genetic mornation is co explain the connection between DNA			
		and proteins,		
Skills	The students can			
	• recognize the importance of molecula	r parameters for the source of a disease:		
	describe selected molecular-diagnos	ar parameters for the course of a disease;		
	 explain the relevance of these proced 			
Personal Competence				
Social Competence	The students can participate in discussions in	n research and medicine on a technical level.		
Autonomy	The students can develop understanding of t	opics from the course, using technical literature, by	themselves	
hatonomy				
Workload in Hours	Independent Study Time 62, Study Time in L	ecture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German prog	ram): Specialisation Mechanical Engineering, Focu	s Biomechanics: Compulse	ory
Curricula	General Engineering Science (German prog	ram): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (German prog	ram, 7 semester): Specialisation Biomedical Engine	eering: Compulsory	
		ram, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechanic	cs: Compulsory
	Electrical Engineering: Specialisation Medica			
		am): Specialisation Mechanical Engineering, Focus		ory
		am): Specialisation Biomedical Engineering: Comp	•	
		am, 7 semester): Specialisation Mechanical Engine		s: Compulsory
		am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Bior			
		agement and Business Administration: Elective Col		
		cial Organs and Regenerative Medicine: Elective C		
		ical Technology and Control Theory: Elective Comp	buisory	
		ants and Endoprostheses: Elective Compulsory		
	Technomathematics: Core qualification: Elec Technomathematics: Specialisation III. Engir			
	LIEGINUMATIETHATICS, SDECIALISATION III, ENGIN			

Course L0386: Introduction to Bio	Course L0386: Introduction to Biochemistry and Molecular Biology		
Тур	Lecture		
Hrs/wk	2		
CP	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		



Module M1333: BIO I: Imp	lants and Fracture Healing			
Courses				
Title		Тур	Hrs/wk	CP
mplants and Fracture Healing (L0376)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Introduction	on into Anatomie" before attending "Implants and F	racture Healing".	
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways h	how bones heal, and the requirements for their exis	stence.	
	The students can name different treatments for	r the spine and hollow bones under given fracture	morphologies.	
01-111-				
Skills	The students can determine the forces acting	within the human body under quasi-static situation	s under specific assumptio	ns.
Personal Competence				
Social Competence	The students can, in groups, solve basic nume	erical modeling tasks for the calculation of internal	forces.	
A	.		,	
Autonomy	The students can, in groups, solve basic nume	erical modeling tasks for the calculation of internal	torces.	
Workload in Hours	Independent Study Time 62, Study Time in Le	octure 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German progra	am): Specialisation Mechanical Engineering, Focus	s Biomechanics: Compulso	ory
Curricula	General Engineering Science (German progra	am): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (German progra	am, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechanic	s: Compulsory
	General Engineering Science (German progra	am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	General Engineering Science (English progra	am): Specialisation Biomedical Engineering: Comp	ulsory	
	General Engineering Science (English progra	am): Specialisation Mechanical Engineering, Focus	Biomechanics: Compulso	ry
	General Engineering Science (English progra	am, 7 semester): Specialisation Mechanical Engine	ering, Focus Biomechanics	s: Compulsory
	General Engineering Science (English progra	am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Biom	echanics: Compulsory		
		ial Organs and Regenerative Medicine: Elective C	ompulsory	
		Ints and Endoprostheses: Elective Compulsory	· · ·	
		cal Technology and Control Theory: Elective Comp	oulsory	
		gement and Business Administration: Elective Cor		
	Technomathematics: Specialisation III. Engine			



ourse L0376: Implants and Fracture Healing		
•	Lecture	
Hrs/wk		
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
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	



Module M1342: Polymers				
-				
Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polymers (LC		Lecture	2	3
Processing and design with polymers (L		Lecture	2	3
Module Responsible				
Admission Requirements	None			
	Basics: chemistry / physics / material science			
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plastics a	and define the necessary testing and analysis.		
	They can explain the complex relationships s	tructure-property relationship and		
	the interactions of chemical structure of the	e polymers, including to explain neighboring	contexts (e.g. sustai	nability, environment
	protection).			-
Skills	Students are capable of			
	- using standardized calculation methods in a	a given context to mechanical properties (moc	lulus, strength) to calc	ulate and evaluate th
	different materials.			
	- For mechanical recycling problems selecting	g appropriate solutions and sizing example Stif	fness, corrosion resist	ance.
Personal Competence				
Social Competence	Students can,			
	- arrive at work results in groups and document	nt them.		
	- provide appropriate feedback and handle fee	edback on their own performance constructively	/.	
Autonomy	Students are able to,			
	- assess their own strengths and weaknesses	3		
	- assess their own state of learning in checific	c terms and to define further work steps on this	s hasis guided by toool	ars
	- assess their own state of learning in specific	terms and to denne futther work steps on this	basis guided by leaci	1615.
	- assess possible consequences of their profe	essional activity.		
Workload in Hours	Independent Study Time 124, Study Time in Lect	ture 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 min		-	
Assignment for the Following	Materials Science: Specialisation Engineering M	aterials: Elective Compulsory		
Curricula	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Compul	sory	
	Product Development, Materials and Production:	Specialisation Production: Elective Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Product Development, Materials and Production:	Specialisation Product Development: Elective Co	ompulsory	
	Theoretical Mechanical Engineering: Specialisat	tion Materials Science: Elective Compulsory		



Course L0389: Structure and Prop	
	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
	Dr. 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 and design with polymers		
Тур	Lecture	
Hrs/wk	2	
CP	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				
ïtle		Тур	Hrs/wk	CP
lioelectromagnetics: Principles and Applications (L0		Lecture	3	5
bioelectromagnetics: Principles and Applications (L0		Recitation Section (small)	2	1
Module Responsible Prof. Chris	tian Schuster			
Admission Requirements None				
	iples of physics			
Knowledge				
Educational Objectives After takin	part successfully, students have reache	d the following learning results		
Professional Competence	part duote blany, stadents nave reasile			
	can explain the basic principles, relat	tionships, and methods of bioelectromagnetics,	i.e. the quantificati	ion and application
•		n define and exemplify the most important physica		
		can give an overview over measurement and r		
		hey can give examples for therapeutic and diag		
medical te		····) ···· g··· ······p··· ·· ··········		
Skills Students k	now how to apply various methods to cha	aracterize the behavior of electromagnetic fields in	biological tissue. In	order to do this they c
		of Maxwell's Equations. They are able to assess	-	
		cts corresponding to wavelength and frequency,		
		on strategies for their predictions. They are able to		
	utic and diagnostic applications and mak			
Personal Competence				
Social Competence Students a	re able to work together on subject relate	ed tasks in small groups. They are able to present	their results effectivel	y in English (e.g. duri
small grou	p exercises).			
		bject related, professional publications and relate		
		their knowledge obtained in this lecture with th		
		al engineering / physics). They can communio	cate problems and	effects in the field
bioelectro	nagnetics in English.			
Workload in Hours Independe	nt Study Time 110, Study Time in Lecture	9 70		
Credit points 6				
Examination Oral exam				
Examination duration and scale 30-60 min	utes			
Assignment for the Following Electrical	ingineering: Specialisation Microwave E	ngineering, Optics, and Electromagnetic Compatib	ility: Elective Compul	sory
Curricula Electrical	Ingineering: Specialisation Medical Tech	nology: Elective Compulsory		
Internation	al Management and Engineering: Specia	alisation II. Electrical Engineering: Elective Compu	sory	
Biomedica	I Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective Compu	Isory	
Biomedica	I Engineering: Specialisation Implants an	nd Endoprostheses: Elective Compulsory		
Biomedica	Engineering: Specialisation Medical Te	chnology and Control Theory: Elective Compulsor	y	
Discossilia	Engineering: Openialization Manageme	ent and Business Administration: Elective Compuls		



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	SoSe
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: Bioelectromagneti	Course L0373: Bioelectromagnetics: Principles and Applications		
Тур	Recitation Section (small)		
Hrs/wk	2		
CP	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
	Prof. Christian Schuster		
0 0			
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)		



Module M1335: BIO II: Ar	ificial Joint Replacement		
Courses			
Title	Түр	Hrs/wk	СР
Artificial Joint Replacement (L1306)	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			
Skill			
Personal Competence			
Social Competence			
Autonom			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following	International Management and Engineering: Specialisation II. Process Engineering and Biot	echnology: Elective Compulsory	
Curricula	Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective	Compulsory	
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective C	Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulso	ry	

Course L1306: Artificial Joint Repl	acement
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	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				
Fitle		Тур	Hrs/wk	CP
Robotics and Navigation in Medicine (LC Robotics and Navigation in Medicine (LC		Lecture Project Seminar	2	3 2
Robotics and Navigation in Medicine (LC		Recitation Section (small)	1	1
	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous				
Knowledge	 principles of math (algebra, analysis/calgebra) 	culus)		
	 principles of programming, e.g., in Java 	or C++		
	 solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence		· · · · · · · · · · · · · · · · · · ·		
Knowledge	The students can explain kinematics and tracking	ng systems in clinical contexts and illustrate systems	and their components	s in details. Systems o
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in details. Systems ca be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.			
Skills	The students are able to design and evaluate na	avigation systems and robotic systems for medical a	pplications.	
Personal Competence				
Social Competence	The students discuss the results of other groups	, provide helpful feedback and can incoorporate fee	dback into their work.	
Autonomy	The students can reflect their knowledge and de	cument the results of their work. They can present th	o rogulto in on oppron	riata mannar
Autonomy	The students can reliect their knowledge and do	cument the results of their work. They can present to	le results in an approp	nate manner.
Workload in Hours	Independent Study Time 110, Study Time in Leo	ture 70		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence E	ngineering: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical T	echnology: Elective Compulsory		
	Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory			
	International Management and Engineering: Sp	ecialisation II. Electrical Engineering: Elective Comp	oulsory	
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificia	Organs and Regenerative Medicine: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medica	Technology and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Manage	ement and Business Administration: Elective Compu	lsory	
	Product Development, Materials and Production	: Specialisation Product Development: Elective Cor	npulsory	
	Product Development, Materials and Production	: Specialisation Production: Elective Compulsory		
	Product Development, Materials and Production	: Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisa	tion Bio- and Medical Technology: Elective Comput	sorv	

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



Тур	Project Seminar	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	
ourse L0336: Robotics and Navi	irse L0336: Robotics and Navigation in Medicine	
Typ	Positiation Social (small)	

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



on into Medical Technology and Syste	ems			
	Тур	Hrs/wk	СР	
d Systems (L0342)	Lecture	2	3	
d Systems (L0343)	Project Seminar	2	2	
d Systems (L1876)	Recitation Section (large)	1	1	
Prof. Alexander Schlaefer				
None				
principles of math (algebra, analysis/calculus)				
principles of stochastics				
principles of programming, R/Matlab				
After taking part successfully, students have reached	d the following learning results			
The students can explain principles of medical tech	nology, including imaging systems, computer aid	ed surgery, and medi	cal information systen	
They are able to give an overview of regulatory affairs and standards in medical technology.				
The students are able to evaluate systems and med	ical devices in the context of clinical applications.			
The students describe a problem in medical technol	ogy as a project, and define tasks that are solved	in a joint effort.		
The students can reflect their knowledge and docum	nent the results of their work. They can present the	e results in an approp	riate manner.	
Independent Study Time 110, Study Time in Lecture	970			
6				
Written exam				
90 minutes				
General Engineering Science (German program): S	pecialisation Biomedical Engineering: Compulso	ry		
General Engineering Science (German program, 7 s	semester): Specialisation Biomedical Engineering	g: Compulsory		
Electrical Engineering: Core gualification: Elective Compulsory				
General Engineering Science (English program): Sp	pecialisation Biomedical Engineering: Compulsor	у		
Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory				
Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory				
Biomedical Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective Compu	ulsory		
Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory			
		ry		
• • •				
	d Systems (L0342) d Systems (L0343) d Systems (L1876) Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reacher The students can explain principles of medical tech They are able to give an overview of regulatory affai The students are able to evaluate systems and med The students describe a problem in medical technol The students can reflect their knowledge and docun Independent Study Time 110, Study Time in Lecture 6 Written exam 90 minutes General Engineering Science (German program): S General Engineering Science (German program): S General Engineering Science (English program): S General Engineering Science and Engineering: Specialiss Computational Science and Engineering: Specialis Biomedical Engineering: Specialisation Implants an Biomedical Engineering: Specialisation Medical Ter	d Systems (L0342) Lecture d Systems (L1876) Project Seminar d Systems (L1876) Recitation Section (large) Prof. Alexander Schlaefer None Principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aid They are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved The students can reflect their knowledge and document the results of their work. They can present the Independent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program): Specialisation Biomedical Engineering: Compulso General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsor <td>Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Rectation Section (large) 1 Prof. Alexander Schlaefer None Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Mattab Ifter taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical technology. The students are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. The students can reflect their knowledge and document the results of their work. They can present the results in an appropindent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program; Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program; 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory General Engineering Scien</td>	Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Rectation Section (large) 1 Prof. Alexander Schlaefer None Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Mattab Ifter taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical technology. The students are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. The students can reflect their knowledge and document the results of their work. They can present the results in an appropindent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program; Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program; 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory General Engineering Scien	

Course L0342: Introduction into Me	edical 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 into M	ourse L0343: Introduction into Medical Technology and Systems		
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	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction into Me	edical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
CP	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.



Iodule M0752: Nonlinear	Dynamics			
Courses				
Title		Тур	Hrs/wk CF	2
Ionlinear Dynamics (L0702)		Lecture	4 6	
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence Knowledge Skills	Students are able to reflect existing terms and conce Students are able to apply existing methods and pro			
Personal 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 no	vel research tasks by themselves.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Computational Science and Engineering: Specialisa International Management and Engineering: Special Mechanical Engineering and Management: Special Mechatronics: Specialisation System Design: Election Mechatronics: Specialisation Intelligent Systems and Biomedical Engineering: Specialisation Artificial Org Biomedical Engineering: Specialisation Implants and	tion Scientific Computing: Elective Compute lisation II. Mechatronics: Elective Compulsor sation Mechatronics: Elective Compulsory re Compulsory d Robotics: Elective Compulsory ans and Regenerative Medicine: Elective C	ry	
	Biomedical Engineering: Specialisation Medical Teo Biomedical Engineering: Specialisation Manageme Product Development, Materials and Production: Co Theoretical Mechanical Engineering: Technical Cor Theoretical Mechanical Engineering: Core qualifica	nt and Business Administration: Elective Con re qualification: Elective Compulsory uplementary Course: Elective Compulsory		

Course L0702: Nonlinear Dynamic	25
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	SoSe
Content	Fundamentals of Nonlinear Dynamics.
Literature	S. Strogatz: Nonlinear Dynamics and Chaos. Perseus, 2013.



Courses				
Title		Тур	Hrs/wk	CP
Semiconductor Technology (L0722)		Lecture Laboratory Course	4	5 2
Semiconductor Technology (L0723)	Prof. Hoc Khiem Trieu	Laboratory Course	2	2
Module Responsible Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science and semiconduc	tor devices		
Knowledge	basics in physics, chemistry, matchar science and semiconduc			
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence		0 0		
Knowledge				
	Students are able			
	 to describe and to explain current fabrication techniques fo 	Si and GaAs substrates,		
	 to discuss in details the relevant fabrication processes, pro integrated circuits and 	cess flows and the impact thereof or	n the fabrication of sem	iconductor devices ar
	to present integrated process flows.			
Skills				
	Students are capable			
	 to analyze the impact of process parameters on the process 	ing results,		
	to select and to evaluate processes and			
	 to develop process flows for the fabrication of semiconduct 	or devices.		
Personal Competence				
Social Competence	Students are able to prepare and perform their lab experiment	in team work as well as to present a	nd discuss the results in	n front of audience.
Autonomy	None			
	Independent Study Time 126, Study Time in Lecture 84			
Credit points	7			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics and Mi	rosystems Technology: Elective Con	npulsory	
Curricula	Biomedical Engineering: Specialisation Artificial Organs and F	egenerative Medicine: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Implants and Endopro	stheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a			
	Biomedical Engineering: Specialisation Management and Bus	ness Administration: Elective Compu	llsory	
	1			



Course L0722: Semiconductor Teo	chnology
	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, 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) Water fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by dilfusion: 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, kinetics, 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 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: excimer laser light source, immersion lithography and phase shift lithography, electron 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, bipola
Literature	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: Semiconductor Tee	urse L0723: Semiconductor Technology		
Тур	Laboratory 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: Humanoid	I Robotics			
Courses				
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk	CP 2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge				
	Students can explain humanoid robots.			
	Students learn to apply basic control concepts	for different tasks in numarioid robotics.		
Skills		meete of humanaid valuation, based on an	alfied literature	
	 Students acquire knowledge about selected as Students generalize developed results and pre 		cilled illerature	
	 Students generalize developed results and pre- Students practice to prepare and give a preser 			
Personal Competence				
Social Competence	 Students are capable of developing solutions i 	n interdisciplinary teams and present them		
	 They are able to provide appropriate feedback 			
Autonomy	 Students evaluate advantages and drawbacks 	of different forms of presentation for speci	fic tasks and select the best	solution
	 Students evaluate advantages and drawbacks Students familiarize themselves with a scien 			
	scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points				
Examination Examination duration and scale	Presentation			
		Nor Systema: Elective Compulsor		
Assignment for the Following Curricula				
Curricula	Mechatronics: Specialisation Intelligent Systems and I Mechatronics: Specialisation System Design: Elective			
	Biomedical Engineering: Specialisation Artificial Orga		ompulsory	
	Biomedical Engineering: Specialisation Antilear Orga Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Implants and Biomedical Engineering: Specialisation Medical Tech		oulsory	
	Biomedical Engineering: Specialisation Management			
	Theoretical Mechanical Engineering: Technical Comp			
	Theoretical Mechanical Engineering: Core qualification			

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



ourses				
tle		Тур	Hrs/wk	CP
near and Nonlinear System Identificati	on (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response	e, root locus)		
	State space methods			
	Discrete-time systems			
	Linear algebra, singular value decom			
	Basic knowledge about stochastic pro	ICESSES		
Educational Objectives	After taking part successfully, students have r	eached the following learning results		
Professional Competence				
Knowledge		manually of the prediction every method and its an	aliantian to a variaty of line	er and nealinear ma
	 Students can explain the general transference structures 	mework of the prediction error method and its app	plication to a variety of line	ar and noninear mo
		eptron networks are used to model poplinear dyna	imics	
	 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 			
	· · · · · · · · · · · · · · · · · · ·		,	
Skills		predicition error method to the experimental identi	ification of linear and nonlin	near models for dyna
	systems			
		nonlinear predictive control scheme based on a ne	ural 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	d software tools (including the Matlab System Iden	tification Toolbox)	
Personal Competence				
Social Competence	Students can work in mixed groups on specifi	ic problems to arrive at joint solutions.		
Autonomy		on in sources provided (lecture notes, literature,	software documentation) a	nd use it to solve give
	problems.			
Workload in Hours	Independent Study Time 62, Study Time in Le	ecture 28		
Credit points	3			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control	I and Power Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artific	cial Organs and Regenerative Medicine: Elective C	Compulsory	
		ants and Endoprostheses: Elective Compulsory		
		ical Technology and Control Theory: Compulsory		
		agement and Business Administration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Technic Theoretical Mechanical Engineering: Core gu	cal Complementary Course: Elective Compulsory		

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



Courses					
		Tun	Hrs/wk	СР	
Title Optimal and Robust Control (L0658)		Typ Lecture	2	3	
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous					
Knowledge	Classical control (frequency response, root locus) State appear methods				
	State space methodsLinear algebra, singular value decomposition				
Educational Objectives	After taking part successfully, students have reached the fo	lowing learning results			
Professional Competence					
Knowledge	 Students can explain the significance of the matrix I 	Riccati equation for the solution of LQ proble	ems		
	They can explain the duality between optimal state				
	They can explain how the H2 and H-infinity norms a		nce constraints.		
	• They can explain how an LQG design problem can	be formulated as special case of an H2 des	ign problem.		
	They can explain how model uncertainty can be replaced as the second secon	presented in a way that lends itself to robust	controller design		
	They can explain how - based on the small gain t	heorem - a robust controller can guarantee	e stability and perfor	mance for an uncer	
	plant.				
	They understand how analysis and synthesis condi	tions on feedback loops can be represented	l as linear matrix ine	qualities.	
Skills					
	Students are capable of designing and tuning LQG They are capable of representing a LIQ or LL infinite.		d alaat and af using	atandard astruces t	
	 They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software too for solving it. 				
	 They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitiv 				
	functions, and of carrying out a mixed-sensitivity design.				
	• They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller.				
	They are capable of formulating analysis and synth	esis conditions as linear matrix inequalities	(LMI), and of using	standard LMI-solver	
	solving them.				
	They can carry out all of the above using standard s	oftware tools (Matlab robust control toolbox).		
Personal Competence					
	e Students can work in small groups on specific problems to arrive at joint solutions.				
Autonomy					
	problems.	• • •	,	-	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering				
Curricula	Electrical Engineering: Specialisation Control and Power S	ystems: Elective Compulsory			
	Energy Systems: Core qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft System Computational Science and Engineering: Specialisation St		Compulsory		
	Mechatronics: Specialisation Intelligent Systems and Robo		Sompulsory		
	Mechatronics: Specialisation System Design: Elective Com				
	Biomedical Engineering: Specialisation Artificial Organs an		sory		
	Biomedical Engineering: Specialisation Implants and Endo	-			
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Compulso	ory		
	Product Development, Materials and Production: Specialis		llsory		
	Product Development, Materials and Production: Specialis				
	Product Development, Materials and Production: Specialise				
	Theoretical Mechanical Engineering: Technical Compleme				
	Theoretical Mechanical Engineering: Core qualification: El	souve compulsory			



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

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



Courses					
Title		Тур	Hrs/wk	CP	
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3	
Module Responsible	Prof. Olaf Simanski				
Admission Requirements	None				
Recommended Previous	Basics in Control, Basics in Physiology				
Knowledge					
Educational Objectives	After taking part successfully, students have re	eached the following learning results			
Professional Competence					
Knowledge	The lecture will introduce into the fascinating	area of medical technology with the engineering	point of view. Fundamenta	als in human physiolo	
	will be similarly introduced like knowledge in a	control theory.			
	Internal control loops of the human body wil	I be discussed in the same way like the design	of external closed loop of	ustom to oxamplo in	
	anesthesia control.	The discussed in the same way like the design	of external closed loop s	ystern to example in	
	anestresia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be il 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 specific pro	blems in small groups and present their results (e	.g. during project week)		
Autonomy		and to set it into the context of the lecture. They			
	and to take control of their learning process. T	hey can combine knowledge from different course	es to form a consistent whol	е.	
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28			
Credit points	3				
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory			
Curricula	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory			
	Biomedical Engineering: Specialisation Artific	ial Organs and Regenerative Medicine: Elective C	Compulsory		
	Biomedical Engineering: Specialisation Impla	nts and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Compulsory			
	Biomedical Engineering: Specialisation Mana	compart and Dusiness Administration, Elective Co	maulaan		

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



Module M1143: Mechanica	al Design Methodology				
Courses					
Title		Тур	Hrs/wk	CP	
Mechanical Design Methodology (L1523)	Lecture	3	4	
Mechanical Design Methodology (L1524)	Recitation Section (small)	1	2	
Module Responsible	Prof. Josef Schlattmann				
Admission Requirements	None				
Recommended Previous					
Knowledge					
Educational Objectives	After taking part successfully, students have reached	the following learning results			
Professional Competence					
Knowledge	Science-based working on product design considering targeted application of specific product design techniques				
Skills	s Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product				
	design techniques following theoretical aspects.				
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	56			
Credit points	6				
Examination	Oral exam				
Examination duration and scale	30 min				
Assignment for the Following	International Management and Engineering: Speciali	sation II. Product Development and Production	Elective Compulsory		
Curricula	Mechatronics: Specialisation System Design: Elective	Compulsory			
	Biomedical Engineering: Specialisation Artificial Orga	ans and Regenerative Medicine: Elective Comp	ulsory		
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective Compulso	ory		
	Biomedical Engineering: Specialisation Managemen	and Business Administration: Elective Compu	lsory		
	Product Development, Materials and Production: Spe	cialisation Product Development: Elective Com	pulsory		
	Product Development, Materials and Production: Spe	cialisation Production: Elective Compulsory			
	Product Development, Materials and Production: Spe	cialisation Materials: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation F	Product Development and Production: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technical Com	plementary Course: Elective Compulsory			

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



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



ourses				
itle		Тур	Hrs/wk	CP
arketing (Innovation Marketing / Sales	and Services) (L0862)	Problem-based Learning	5	6
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous				
Knowledge	Module International Business Basia understanding of husiness administration	principles (strategic planning decision (theory project ma	nagoment interneti
	 Basic understanding of business administration business) 	principles (strategic planning, decision	meory, project ma	nagement, internatio
	 Bachelor-level Marketing Knowledge (Marketing In 	struments. Market and Competitor Strategies	s. Basics of Buving B	Behavior)
	 Understanding of differences in the market introduce 		,	
	 Unerstanding the differences beweetn B2B and B2 			
	Understanding of the importance of managing inno	vation in global industrial markets		
	Good English proficiency; presentation skills			
Educational Objections				
Educational Objectives Professional Competence	After taking part successfully, students have reached the for	llowing learning results		
Knowledge	Students will have gained a deep understanding of			
ritiomeage				
	Specific characteristics in the marketing of innovativ			
	 The importance of product-related and independent 			
	Approaches for analyzing the current market situati			
	The gathering of information about future customer Concepts and approaches to integrate lead uppro		alanmantaraaaaaa	
	 Concepts and approaches to integrate lead users a Approaches and tools for ensuring customer-orient 			
	 Marketing mix elements that take into consideration 			
	 Pricing methods for new products and services 			
	 The organization of complex sales forces and personal sectors. 	onal 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 market 	ing and innovation strategies		
	 Analyze markets by applying market and technolog 			
	 Conduct forecasts and develop compelling scenario 			
	Translate customer needs into concepts, prototype concepts, p	pes and marketable offers and successful	ly apply advanced	methods for custor
	oriented product and service development			
	Use adequate methods to foster efficient diffusion of	f innovative products and services		
	Choose suitable pricing strategies and communication	tion activities for innovations		
	 Make strategic sales decisions for products and ser 	vices (i.e. selection of sales channels)		
	 Apply methods of sales force management (i.e. cus 	tomer 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			
, atomotiny				
	 Acquire knowledge independently in the specific control 		ew complex probler	n fields.
	Consider proposed business actions in the field of	narketing and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisation	I. Electives Management: Elective Compute	sory	
Curricula	Mechanical Engineering and Management: Specialisation	Management: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs an	nd Regenerative Medicine: Elective Compute	sory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technolog	gy and Control Theory: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and	Business Administration: Compulsory		



_				
	Problem-based Learning 5			
	6			
	Independent Study Time 110, Study Time in Lecture 70			
	Prof. Christian Lüthje			
Cycle	SoSe			
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. Mapping Techniques			
	Perceptual Maps, Gap Model			
	ser innovations			
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis			
	VI. 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			
	XI. Communications			
	Diffusion of Innovations, Communication Objectives, Communication Instruments			
	Kotler, P., Keller, K. L. (2006). Marketing Management, 12 th edition, Pearson Prentice Hall, New Jersey Bo Edvardsson et. al. (2006) Involving Customers in New Service Development, London			
	Joe Tidd & Frank M. Hull (Editors) (2007) Service Innovation, London			
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press			
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008			



Courses					
litle		Тур	Hrs/wk	CP	
Bioprocess Engineering - Fundamentals	(L0841)	Lecture	2	3	
Bioprocess Engineering- Fundamentals		Recitation Section (large)	2	1	
Bioprocess Engineering - Fundamental F	Practical Course (L0843)	Laboratory Course	2	2	
Module Responsible	Prof. Andreas Liese				
Admission Requirements	None				
Recommended Previous	none, module "organic chemistry", module "fundamer	tals for process engineering"			
Knowledge					
Educational Objectives	After taking part successfully, students have reached	he following learning results			
Professional Competence					
Knowledge	Students are able to describe the basic concepts of I	pioprocess engineering. They are able to classif	/ different types of I	kinetics for enzymes	
	microorganisms, as well as to differentiate different	ypes of inhibition. The parameters of stoichiom	etry and rheology c	an be named and m	
	transport processes in bioreactors can be explained	d. The students are capable to explain fundam	ental bioprocess m	anagement, steriliza	
	technology and downstream processing in detail.				
o					
Skills	After successful completion of this module, students s	hould be able to			
	 describe different kinetic approaches for growthing the second sec	h and substrate-uptake and to calculate the corre	sponding paramete	ers	
	 predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentatio 				
	process				
	 analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations 				
	• distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compar				
	them as well as to apply them to current biotechnical problem				
	 propose solutions to complicated biotechnological problems and to deduce the corresponding models 				
	 to evaluate new knowledge recourses and to apply the newly gained contents. 				
	 to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions 				
	 identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 				
	• to document and discuss their procedures as				
Personal Competence					
-	After completion of this module participants should be	e able to debate technical questions in small tea	ms to enhance the	ability to take positio	
oocial competence	their own opinions and increase their capacity for teal			ability to take positio	
			-		
Autonomy	After completion of this module participants will be at	le to solve a technical problem in a team indepe	ndently by organizi	ng their workflow and	
	present their results in a plenum.				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84				
Credit points	6				
Examination					
Examination duration and scale	90 min				
Assignment for the Following	General Engineering Science (German program): Spe	5 5 I ,			
Curricula	General Engineering Science (German program): Spe				
	General Engineering Science (German program, 7 se				
	General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory				
	Bioprocess Engineering: Core qualification: Compulsory				
	General Engineering Science (English program): Spe				
	General Engineering Science (English program): Spe		maulaar		
	General Engineering Science (English program, 7 se	, ,			
	General Engineering Science (English program, 7 set		Jompulsory		
	Biomedical Engineering: Specialisation Artificial Orga	•			
	Biomedical Engineering: Specialisation Implants and				
	Biomedical Engineering: Specialisation Medical Tech				
	Biomedical Engineering: Specialisation Management		иу		
	Technomathematics: Specialisation III. Engineering S				
	Process Engineering: Core qualification: Compulsory				



Course L0841: Bioprocess Engine					
Тур	Lecture				
Hrs/wk	2				
CP					
Workload in Hours	lependent 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) Technology of sterilization (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 Engine	ourse L0842: Bioprocess Engineering- Fundamentals		
Тур	Recitation Section (large)		
Hrs/wk	2		
CP	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language			
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 Engine	ering - Fundamental Practical Course
Тур	Laboratory Course
Hrs/wk	2
CP	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					
Courses		_			
Fitle		Typ Lecture	Hrs/wk 2	СР 3	
Introduction to Anatomy (L0384)	Prof. Udo Schumacher	Lecture	2	3	
Module Responsible					
Admission Requirements					
Recommended Previous					
Knowledge					
Educational Objectives	· · ·	following learning results			
Professional Competence					
Knowledge		-	eletal system.		
	The students can describe the basic macroscopy and mic	croscopy of those systems.			
Skills	The students can recognize the relationship between give	ven anatomical facts and the develop	ment of some common dise	ases; they can expl	
	the relevance of structures and their functions in the conte	ext of widespread diseases.			
Personal Competence					
Social Competence	The students can participate in current discussions in bio	medical research and medicine on a p	rofessional level.		
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the releva				
hateneng	knowledge themselves.				
	······································				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	General Engineering Science (German program): Specia	lisation Mechanical Engineering, Focu	is Biomechanics: Compulso	ry	
Curricula	General Engineering Science (German program): Specia	lisation Biomedical Engineering: Com	pulsory		
	General Engineering Science (German program, 7 seme	ster): Specialisation Biomedical Engine	eering: Compulsory		
	General Engineering Science (German program, 7 seme	ster): Specialisation Mechanical Engin	eering, Focus Biomechanics	s: Compulsory	
	Electrical Engineering: Specialisation Medical Technolog	y: Elective Compulsory			
	General Engineering Science (English program): Special	isation Mechanical Engineering, Focu	s Biomechanics: Compulsor	У	
	General Engineering Science (English program): Special	isation Biomedical Engineering: Comp	oulsory		
	General Engineering Science (English program, 7 semes	ter): Specialisation Mechanical Engine	eering, Focus Biomechanics	: Compulsory	
	General Engineering Science (English program, 7 semes	ter): Specialisation Biomedical Engine	ering: Compulsory		
	Mechanical Engineering: Specialisation Biomechanics: C	Compulsory			
	Biomedical Engineering: Specialisation Medical Technology	ogy and Control Theory: Elective Com	oulsory		
	Biomedical Engineering: Specialisation Management and	d Business Administration: Elective Co	mpulsory		
	Biomedical Engineering: Specialisation Artificial Organs a	and Regenerative Medicine: Elective C	Compulsory		
	Biomedical Engineering: Specialisation Implants and End	toprostheses: Elective Compulsory			
	Technomathematics: Specialisation III. Engineering Scier				



Typ	Lecture		
Hrs/wk			
CP			
Workload in Hours	ependent Study Time 62, Study Time in Lecture 28		
Lecturer			
Language			
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/Michael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag Stuttgart, 2012		



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Courses		-				
Fitle ntroduction to Radiology and Radiation ⁻	herapy (L0383)	Typ Lecture	Hrs/wk 2	СР 3		
Module Responsible	Prof. Ulrich Carl			•		
Admission Requirements	None					
Recommended Previous Knowledge	None					
Educational Objectives	After taking part successfully, students have reache	ed the following learning results				
Professional Competence						
Knowledge	Therapy The students can distinguish different types of current	ently used equipment with respect to its use in	n radiation therapy.			
	The students can explain treatment plans used 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 base condition imaging techniques (CT, MRT, US).	epts of projection radiography, including an	giography and mammograp	bhy, as well as section		
	The students can explain the diagnostic as well as	therapeutic use of imaging techniques, as w	ell as the technical basis for	those techniques.		
	The students can choose the right treatment metho	d depending on the patient's clinical history a	and needs.			
	The student can explain the influence of technical e	errors on the imaging techniques.				
	The student can draw the right conclusions based	on the images' diagnostic findings or the erro	r protocol.			
Skills	Therapy The students can distinguish curative and palliative	e situations and motivate why they came to th	at conclusion.			
	The students can develop adequate therapy conce	pts and relate it to the radiation biological as	pects.			
	The students can use the therapeutic principle (effe	ects vs adverse effects)				
	The students can distinguish different kinds of rad the energy needed in that situation (irradiation plan		on the situation (location of	the tumor) and choo		
	The student can assess what an individual psych groups, social services, psycho-oncology).	osocial service should look like (e.g. follow-	up treatment, sports, socia	l help groups, self-h		
	Diagnostics					
The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.						
	The students can classify results of imaging technic and pathophysiology.	ques according to different groups of disease	s based on their knowledg	e of anatomy, patholo		
Personal Competence						
Social Competence	The students can assess the special social situatio The students are aware of the special, often fear-do them appropriately.			measures and can m		
Autonomy	The students can apply their new knowledge and s	kills to a concrete therapy case.				
	The students can introduce younger students to the clinical daily routine.					
	The students are able to access anatomical knowl relevant knowledge themselves.	edge by themselves, can participate compet	ently in conversations on the	ie topic and acquire		
Workload in Hours	Independent Study Time 62, Study Time in Lecture	28				
Credit points	3					
Examination	Written exam					
Examination duration and scale	90 minutes					
Assignment for the Following	General Engineering Science (German program): S			ory		
Curricula	General Engineering Science (German program): General Engineering Science (German program, 7					
	General Engineering Science (German program, 7 General Engineering Science (German program, 7	, ,	• • •	s: Compulsory		
	Electrical Engineering: Specialisation Medical Tech		<u>.</u>	. ,		
	General Engineering Science (English program): S			ry		
	General Engineering Science (English program): S			Compulsor		
	General Engineering Science (English program, 7 General Engineering Science (English program, 7		-	s. compulsory		
	Mechanical Engineering: Specialisation Biomecha	, , ,				
	Biomedical Engineering: Specialisation Medical Te Biomedical Engineering: Specialisation Manageme					

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 TUHH

Course L0383: Introduction to Rac	liology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	
Lecturer Language	Prof. Ulrich Carl, Prof. Thomas Vestring DE
	SoSe
	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 f ür 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



Module M1280: MED II: Int	roduction to Physiology				
Courses					
Title		Тур	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 re	eached the following learning results			
Professional Competence					
Knowledge	The students can				
	 describe the basics of the energy meta 	abolism;			
	describe physiological relations in sele	ected fields of muscle, heart/circulation, neuro- and s	ensory physiology.		
Skills	The students can describe the effects of basi	c bodily functions (sensory, transmission and proce	ssing of information, dev	velopment of forces a	
	vital functions) and relate them to similar tech		0		
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	e, by themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Le	cture 28			
Credit points	3				
Examination	Written exam				
Examination duration and scale	60 minutes				
Assignment for the Following	General Engineering Science (German progra	am): Specialisation Mechanical Engineering, Focus I	Biomechanics: Compulse	ory	
Curricula	General Engineering Science (German progra	am): Specialisation Biomedical Engineering: Compu	lsory		
	General Engineering Science (German progra	am, 7 semester): Specialisation Biomedical Engineer	ring: Compulsory		
		am, 7 semester): Specialisation Mechanical Enginee	ring, Focus Biomechanic	cs: Compulsory	
	Electrical Engineering: Specialisation Medica				
		am): Specialisation Mechanical Engineering, Focus E		ory	
		am): Specialisation Biomedical Engineering: Compul	•		
		am, 7 semester): Specialisation Mechanical Engineer		s: Compulsory	
		am, 7 semester): Specialisation Biomedical Engineer	ing: Compulsory		
	Mechanical Engineering: Specialisation Biom				
		cal Technology and Control Theory: Elective Compu			
	• • •	agement and Business Administration: Elective Comp			
	• • •	ial Organs and Regenerative Medicine: Elective Cor	npulsory		
	• • •	ints and Endoprostheses: Elective Compulsory			
	Technomathematics: Core qualification: Elect				
	Technomathematics: Specialisation III. Engine	eering Science: Elective Compulsory			

Course L0385: Introduction to Physiology	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Roger Zimmermann
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	CP
Experimental Methods in Biomechanics	(L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implantate und Fi	akturheilung" before attending "Experime	ntelle 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 bo	nes heal, and the requirements for their ex	distence.	
	The students can name different treatments for the sp	ine and hollow bones under given fracture	e morphologies.	
	The students can describe different measurement tec	nniques for forces and movements, and c	noose the adequate techniqu	ue for a given task.
Skills	The students can describe the basic handling of seve	ral experimental techniques used in biom	echanics.	
D 10				
Personal Competence	The students can in groups calls basis superiments	l te elce		
Social Competence	The students can, in groups, solve basic experimenta	I IASKS.		
Autonomy	The students can, in groups, solve basic experimenta	I tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 20	2		
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): Sp	existing Mechanical Engineering Fee	un Piamanhanian: Compulsa	2
Curricula	General Engineering Science (German program): Sp			Ty
Guincula	General Engineering Science (German program), Sp General Engineering Science (German program, 7 se			e: Compulsory
	General Engineering Science (German program, 7 se	, , ,		a. Computatiy
	General Engineering Science (English program): Spe	, ,	• • •	
	General Engineering Science (English program): Spe	• •		N .
	General Engineering Science (English program, 7 se	• •		-
	General Engineering Science (English program, 7 se	, ,		in compared by
	Mechanical Engineering: Specialisation Biomechanic	, , , ,		
	Biomedical Engineering: Specialisation Artificial Orga		Compulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech		npulsorv	
	Biomedical Engineering: Specialisation Managemen			
	Technomathematics: Specialisation III. Engineering S			

Course L0377: Experimental Meth	Course 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	



0				
Courses				
Title		Тур	Hrs/wk	CP
Practical Course Introduction to Cell Cul	ture (L0350)	Laboratory Course	3	3
Regenerative Medicine (L0347)	Durch Delf Dänte en	Seminar	2	3
Module Responsible Admission Requirements				
Recommended Previous	None For the "Practical course Introduction to cell culture" particip:	ation in locture "Paganarativa madiaina"		
Knowledge	For the Practical course introduction to cell culture participa	ation in recture Regenerative medicine		
Educational Objectives	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence	Alter taking part successiony, students have reached the foll	owing learning results		
	After successful completion of the module students will be	his to dependent the basis methods of w	a a na stativa madiaina a	nd to overlain the use o
Knowledge			•	
	the tissue cells for different methods of tissue engineering human cells.	They are able to give a basic overvie	w of methods for the c	ulivation of animal an
	numan cens.			
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 carry out basic cell culture methods and the c 	orresponding analysis independently		
Personal Competence				
Social Competence	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			
	Students are able to reflect their work orally and discuss it w	in other students and teachers.		
Autonomy				
	After completion of this module, participants will be able to	solve a technical problem in teams of a	approx. 2-4 persons inc	lependently including
	presentation of the results.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Presentation			
Examination duration and scale	Oral presentation + discussion (30 min) + protocol internship)		
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Compulsory		
Curricula	Biomedical Engineering: Specialisation Implants and Endop	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Compu	Ilsorv	

Course L0350: Practical Course Introduction to Cell Culture		
Тур	Laboratory Course	
Hrs/wk	3	
CP	3	
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42	
Lecturer	Prof. Ralf Pörtner	
Language	DE	
Cycle	SoSe	
Content	Introduction to basic skills for cultivation of mammalian cells	
	compact practical course	
Literature		
	Lindl, T. und Gstraunthaler, G.: Zell- und Gewebekultur. Von den Grundlagen zur Laborbank. Spektrum Akademischer Verlag; 6. Auflage 2008.	



One of the test of the second se	
Course L0347: Regenerative Medi	
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE/EN
Cycle	SoSe
Content	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



Courses				
litle		Тур	Hrs/wk	CP
Advanced Topics in Control (L0661)		Lecture	2 2	3 3
Advanced Topics in Control (L0662)	Durf I I - de sub M - de su	Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sensitivity design, linear n	natrix inequalities		
Ţ	After taking part augenegilly, students have reached the f	Newing Learning results		
Educational Objectives	After taking part successfully, students have reached the for	showing learning results		
Professional Competence Knowledge				
Knowledge	Students can explain the advantages and shortcor	nings of the classical gain scheduling appro-	ach	
	They can explain the representation of nonlinear s	ystems in the form of quasi-LPV systems		
	They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions			
	They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems			
	 They are familiar with polytopic and LFT represent 	ations of LPV systems and some of the basi	c synthesis technique	es associated with ea
	of these model structures			
	Students can explain how graph theoretic concept		opology of multiagen	t systems
	They can explain the convergence properties of fill They can explain and write and eventuals condition		The st DV execution	dele
	They can explain analysis and synthesis condition	s for formation control loops involving either	LITOT LPV agent mo	ueis
	 Students can explain the state space represen 	ation of spatially invariant distributed sys	tems that are discr	etized according to a
	actuator/sensor array	auon or spatially invaliant distributed sys		elized according to a
	 They can explain (in outline) the extension of the b 	ounded real lemma to such distributed syste	ems and the associat	ed synthesis condition
	for distributed controllers			
Skills	 Students are capable of constructing LPV mod 	els of nonlinear plants and carry out a	mixed-sensitivity des	sian of gain-schedule
	controllers; they can do this using polytopic, LFT or			
	They are able to use standard software tools (Matla			
	 Students are able to design distributed formation 	controllers for groups of agents with eithe	er LTI or LPV dynam	nics, using Matlab too
	provided			-
	Students are able to design distributed controllers	for spatially interconnected systems, using th	ne Matlab MD-toolbo	x
	-			
Personal Competence				
	e Students can work in small groups and arrive at joint results.			
Autonomy	V Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve give			
	problems.			
Markles dis Harma	Indopendent Study Time 104 Study Time in Lesting 50			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points	oral exam			
Examination				
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineerin			
Curricula	Electrical Engineering: Specialisation Control and Power			
	Electrical Engineering: Specialisation Control and Power			
	Aircraft Systems Engineering: Specialisation Aircraft Syste		Compulsory	
	Computational Science and Engineering: Specialisation S International Management and Engineering: Specialisatio		Compuisory	
	Mechatronics: Specialisation System Design: Elective Cor			
	Mechatronics: Specialisation System Design: Liective Con Mechatronics: Specialisation Intelligent Systems and Rob			
	Biomedical Engineering: Specialisation Implants and End			
	Biomedical Engineering: Specialisation Artificial Organs a		sory	
	Biomedical Engineering: Specialisation Management and	-		
	Biomedical Engineering: Specialisation Medical Technolo		•	
	Theoretical Mechanical Engineering: Core qualification: E	lective Compulsory		



Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	Linear Parameter-Varying (LPV) Gain Scheduling
	- Linearizing gain scheduling, hidden coupling
	- Jacobian linearization vs. quasi-LPV models
	- Stability and induced L2 norm of LPV systems
	- Synthesis of LPV controllers based on the two-sided projection lemma
	- Simplifications: controller synthesis for polytopic and LFT models
	- Experimental identification of LPV models
	- Controller synthesis based on input/output models
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator
	Control of Multi-Agent Systems
	- Communication graphs
	- Spectral properties of the graph Laplacian
	- First and second order consensus protocols
	- Formation control, stability and performance
	- LPV models for agents subject to nonholonomic constraints
	- Application: formation control for a team of quadrotor helicopters
	Control of Spatially Interconnected Systems
	- Multidimensional signals, I2 and L2 signal norm
	- Multidimensional systems in Roesser state space form
	- Extension of real-bounded lemma to spatially interconnected systems
	- LMI-based synthesis of distributed controllers
	- Spatial LPV control of spatially varying systems
	- Applications: control of temperature profiles, vibration damping for an actuated beam
Literature	
	Werner, H., Lecture Notes "Advanced Topics in Control"

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



Module M1227: Lecture Ti	issue Engineering - Regenerative Medicin	е		
Courses				
Title		Тур	Hrs/wk	СР
Lecture Tissue Engineering - Regeneral	tive Medicine (L1664)	Seminar	2	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	After successful completion of the module students car explain the basic udnerlying principles of the discussed to		Engineering and regenerat	ive medicine and ca
	After successful completion of the module students will regenerative medicine.	be able to to analyse and evaluate c	urrent research topics for Ti	ssue Engineering an
Personal Competence				
Social Competence	Students are able to work together as a team with several students to solve given tasks and discuss their results in the plenary and to defend them			
Autonomy	The students are able to present independently the results of their subtasks in a presentation			
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6			
Examination	Written elaboration			
Examination duration and scale	written report (10 pages)	written report (10 pages)		
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory			
Curricula	Biomedical Engineering: Specialisation Implants and En	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Elective Co	mpulsory	

Course L1664: Lecture Tissue Engineering - Regenerative Medicine		
Тур	Seminar	
Hrs/wk	2	
CP	6	
Workload in Hours	Independent Study Time 152, 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	



Specialization Medical Technology and Control Theory

Module M0623: Intelligent	Systems in Medicine			
Courses				
Title		Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331)		Lecture	2	3
Intelligent Systems in Medicine (L0334)		Project Seminar	2	2
Intelligent Systems in Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous				
Knowledge	principles of math (algebra, analysis/calculus)			
	principles of stochastics			
	 principles of programming, Java/C++ and R/Matlab 			
	advanced programming skills			
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge				
	planning. They are able to explain methods for classification a	nd their respective advantages and dis	advantages in clinica	I contexts. The students
	can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and exp		nical data and explain	
	challenges due to the clinical nature of the data and its acquisi	tion and due to privacy and safety requ	irements.	
Skills	The students can give reasons for selecting and adapting me		nd prediction. They c	an assess the methods
	based on actual patient data and evaluate the implemented me	ethods.		
Personal Competence				
Social Competence	The students discuss the results of other groups, provide helpfu	ul feedback and can incoorporate feedb	back into their work.	
Autonomy	The students can reflect their knowledge and document the res	sults of their work. They can present the	results in an appropr	rate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering: El	ective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical Technology: Ele	ctive Compulsory		
	Computational Science and Engineering: Specialisation System	ms Engineering and Robotics: Elective	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Robotics:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and R	egenerative Medicine: Elective Compu	llsory	
	Biomedical Engineering: Specialisation Implants and Endopros	stheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a	nd Control Theory: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Management and Bus	iness Administration: Elective Compuls	ory	
	Theoretical Mechanical Engineering: Specialisation Bio- and N	ledical Technology: Elective Compulso	ory	
	Theoretical Mechanical Engineering: Technical Complemental	ry Course: Elective Compulsory		

Course L0331: Intelligent Systems	s 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



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

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



Courses				
Title		Тур	Hrs/wk	CP
Intelligent Autonomous Agents and Cogr	itive Robotics (L0341)	Lecture	2	4
Intelligent Autonomous Agents and Cogr	itive 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 reache	d the following learning results		
Professional Competence				
Knowledge	Students can explain the agent abstraction, define		-	
	environments). They can describe the main feature			
	decision problems and algorithms for solving these			
	Bayesian networks can be employed as a knowled can define decision making procedures in simple a			-
	context, students can describe techniques for so			
	measuring the value of information. Students car			
	techniques for achieving desired states. Students			
	different types of equilibria, social choice functions,		-	
Skills Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian netwo				
	networks and apply bayesian reasoning for simple			
	scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situation students will apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply techniques for finding different equilibria states, e.g., Nash equilibria.			
	different voting protocols and compare and explain		an agoin accision me	ang sudents will up
	and a second			
Personal Competence				
Social Competence	Students are able to discuss their solutions to proble	ems with others. They communicate in English		
Autonomy	Students are able of checking their understanding of	of complex concepts by solving varaints of concre	ete problems	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	9 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence Engi	neering: Elective Compulsory		
Curricula	Computational Science and Engineering: Specialis	ation Systems Engineering and Robotics: Electiv	ve Compulsory	
	International Production Management: Specialisation	on Production Technology: Elective Compulsory		
	International Management and Engineering: Specia	alisation II. Information Technology: Elective Con	npulsory	
	Mechatronics: Technical Complementary Course: E	lective Compulsory		
	Biomedical Engineering: Specialisation Artificial Or	gans and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants an			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme	at and Durate and Advatation time. Flanting Operation	leemi	



Course L0341: Intelligent Autonom	nous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning Game theory (Golden Balls: Split or Share) Decision's with multiple agents, Nash equilibrium, Bayes-Nash equilibrium Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satt

Course L0512: Intelligent Autonom	Course L0512: Intelligent Autonomous Agents and Cognitive Robotics	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	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 M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of	f Implants (L1588)	Lecture	2	3
Experimental Methods for the Character	zation of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1	583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)		Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Compulso	ry	
			-	

Course L1663: Nature's Hierarchie	cal 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



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 scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful t engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior 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 antennas 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 Way	Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Тур	Recitation Section (small)	
Hrs/wk	2	
CP	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	30 min	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Course L1588: Development and I	Regulatory Approval of Implants	
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE/EN	
Cycle	SoSe	
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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. 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
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Courses 1120, Six Simme		
Course L1130: Six Sigma		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	 Introduction and structuring Basic terms of quality management Measuring and inspection equipment Tools of quality management: FMEA, QFD, FTA, etc. Quality management methodology Six Sigma, DMAIC 	
Literature	Pfeifer, T.: Qualitätsmanagement : Strategien, Methoden, Techniken, 4. Aufl., München 2008 Pfeifer, T.: Praxishandbuch Qualitätsmanagement, München 1996 Geiger, W., Kotte, W.: Handbuch Qualität : Grundlagen und Elemente des Qualitätsmanagements: Systeme, Perspektiven, 5. Aufl., Wiesbaden 2008	



Тур		
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	
	Introduction into Computational Fluid Dynamics	
Literature		
	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.	
	 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 Strömungen. Springer Verla Berlin, Heidelberg, New York, 2006. 	
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag GmbH, Wiesbaden, 2008. 	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GV	
	Fachverlage GmbH, Wiesbaden, 2009.	
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.	
	 Schade, H., Kalle, E.: Submangsleine: Verlag de Groyer, beinn, New York, 2007. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berl 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 L0379: Ceramics Technology		
Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Dr. Rolf Janßen	
Language	DE/EN	
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	



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

Courses				
ïtle		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Antennas, a	nd Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
evelopment and Regulatory Approval o	f Implants (L1588)	Lecture	2	3
xperimental Methods for the Character	ization of Materials (L1580)	Lecture	2	3
Iumerical Methods in Biomechanics (L1	583)	Seminar	2	3
eminar Biomedical Engineering (L1890		Seminar	2	3
ix Sigma (L1130)		Lecture	2	3
luid Mechanics II (L0001)		Lecture	2	4
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 Following	Biomedical Engineering: Specialisation Artificial Orga	ans and Regenerative Medicine: Elective Compute	sory	
Curricula	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tech	nnology and Control Theory: Elective Compulsory		

Course L1663: Nature's Hierarchical 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	



Turn	Lecture
,,	
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	
Lecturer	
Language	
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagne Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful f engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avior 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 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
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course



Course L1588: Development and Regulatory Approval of Implants		
	ecture	
Hrs/wk		
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
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	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE/EN	
Cycle	SoSe	
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 Method	s in Biomechanics
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	90 Minuten
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 Biomedic	Course L1890: Seminar Biomedical Engineering	
Тур	Seminar	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and scale	schriftliche ausarbeitung und Vortrag (20 min)	
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

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



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	
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, Franklurt (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 Strömungen. Springer Verla Berlin, Heidelberg, New York, 2006.
	 Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlag GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GW
	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. Springer-Verlag, Berli 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 L0379: Ceramics Technol	logy			
Тур	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Klausur			
Examination duration and scale	90 Minuten			
Lecturer	r. Rolf Janßen			
Language	E/EN			
Cycle	ViSe			
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			



Module M1334: BIO II: Bio	materials			
Courses				
Title		Тур	Hrs/wk	CP
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	wing learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisation II.	Process Engineering and Biotech	nology: Elective Compulso	ry
Curricula	Materials Science: Specialisation Nano and Hybrid Materials:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and I	Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopre	ostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a	and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Bus	siness Administration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Technical Complementa	ary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and	Medical Technology: Elective Cor	npulsory	



Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk CP	3
Workload in Hours	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 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 M0746: Microsyst	em Engineering				
noutre mor 40. microsyst					
Courses					
Title		Тур	Hrs/wk	CP	
Microsystem Engineering (L0680)		Lecture	2	4	
Microsystem Engineering (L0682)		Problem-based Learning	1	1	
Microsystem Engineering (L0681)		Recitation Section (small)	1	1	
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	None				
Recommended Previous	Basic courses in physics, mathematics and electric er	ngineering			
Knowledge					
Educational Objectives	After taking part successfully, students have reached	the following learning results			
Professional Competence					
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.				
01.11	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.				
Skills	Students are able to analyze and describe the functio	nal behaviour of MEMS components and to evalu	late the potential of i	nicrosystems.	
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 Time 124, Study Time in Lecture 5	66			
Credit points	6				
Examination	Written exam				
Examination duration and scale	2h				
Assignment for the Following	Electrical Engineering: Core qualification: Compulsor	у			
Curricula	Computational Science and Engineering: Specialisat	ion Systems Engineering and Robotics: Elective	Compulsory		
	International Management and Engineering: Speciali	sation II. Electrical Engineering: Elective Compute	sory		
	International Management and Engineering: Speciali	sation II. Mechatronics: Elective Compulsory			
	Mechanical Engineering and Management: Specialisation Mechatronics: 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 Tech	nology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Compulse	ory		
	Microelectronics and Microsystems: Core qualification	a: Elective Compulsory			



Course L0680: Microsystem Engineering Typ Lecture Hrs/wk 2 CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Prof. Manfred Kasper Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography Film deposition Film deposition
Hrs/wk 2 CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Prof. Manfred Kasper Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Prof. Manfred Kasper Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Prof. Manfred Kasper Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
Lecturer Prof. Manfred Kasper Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
Language EN Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
Cycle WiSe Content Object and goal of MEMS Scaling Rules Lithography
Content Object and goal of MEMS Scaling Rules Lithography
Scaling Rules Lithography
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 Engin	Course L0682: Microsystem Engineering		
Тур	Problem-based Learning		
Hrs/wk	1		
CP	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Manfred Kasper		
Language	EN		
Cycle	WiSe		
Content	Examples of MEMS components		
	Layout consideration Electric, thermal and mechanical behaviour		
	Design aspects		
Literature	Wird in der Veranstaltung bekannt gegeben		

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



Module M0751: Vibration	Theory			
	Theory			
Courses				
Title		Тур	Hrs/wk	CP
Vibration Theory (L0701)		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	ng learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration Th	eory and develop them further.		
Skills	Students are able to denote methods of Vibration Theory and d	evelop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vil	ration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following	Energy Systems: Core qualification: Elective Compulsory			
Curricula	Computational Science and Engineering: Specialisation Scient	fic Computing: Elective Compul	lsory	
	International Management and Engineering: Specialisation II. N	lechatronics: Elective Compulso	ory	
	Biomedical Engineering: Specialisation Artificial Organs and Re	egenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopros			
	Biomedical Engineering: Specialisation Medical Technology ar	d Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management and Busi		ompulsory	
	Product Development, Materials and Production: Core qualifica			
	Naval Architecture and Ocean Engineering: Core qualification:			
	Theoretical Mechanical Engineering: Core qualification: Electiv			
	Theoretical Mechanical Engineering: Technical Complementar	Course: Elective Compulsory		

Course L0701: Vibration Theory	
Тур	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	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		Тур	Hrs/wk	СР
Microsystems Technology (L0724)		Lecture	2	4
Microsystems Technology (L0725)		Problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, mechanics and semiconductor teo	hnology		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ng learning results		
Professional Competence				
Knowledge	Students are able			
	 to present and to explain current fabrication techniques f 	or microstructures and especially meth	ods for the fabrication	on of microsensors a
	microactuators, as well as the integration thereof in more comp			
	 to explain in details operation principles of microsensors an 	d microactuators and		
	· to discuss the potential and limitation of microsystems in ap	plication.		
Skills	Students are capable			
	 to analyze the feasibility of microsystems, 			
	 to develop process flows for the fabrication of microstructure 	es and		
	to apply them.			
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab experiments	in team work as well as to present and	discuss the results in	n front of audience.
		,		
Autonomy	None			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Examination Examination duration and scale	Oral exam			
	30 min	resustants Technology: Elective Commu	lson	
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Mic Electrical Engineering: Specialisation Medical Technology: Ele		isory	
Guilleula	Computational Science and Engineering: Specialisation System		Compulsorv	
	International Management and Engineering: Specialisation 0,986			
	Biomedical Engineering: Specialisation Artificial Organs and R		sory	
	Biomedical Engineering: Specialisation Implants and Endopros	•	-	
	Biomedical Engineering: Specialisation Medical Technology ar			
	Biomedical Engineering: Specialisation Management and Busi	ness Administration: Elective Compulso	ry	
	Microelectronics and Microsystems: Core qualification: Elective	Compulson		



Course L0724: Microsystems Tec	nnology
Тур	Lecture
Hrs/wk	2
CP	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: baca sputtering, plasma etching, RE, Bosch process, crop process, XeF2 etching) Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origar 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 (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magnetoresistive and fabrication process; pellistor and thermal conductivity sensor; microle 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, microfluidic witching elements, microreactor, lab-on-a-chip, microanalytics) Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microfluidics witching elements, microreactor, lab-on-a-chip, microanalyt
	 Pesign, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysic FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip ch bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; mice 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 Tec	Course L0725: Microsystems Technology	
Тур	Problem-based Learning	
Hrs/wk	2	
CP	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				
litle		Тур	Hrs/wk	CP
Fechnology Management (L0849)		Problem-based Learning	3	3
Fechnology Management Seminar (L08	50)	Problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements				
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
	Students will gain deep insights into:			
	Technology Timing Strategies			
	 Technology Strategies and Lifecycle 	e Management (I/II)		
	 Technology Intelligence and Planni 			
	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 on understanding of the important	es of Tachaology Managament , on a patienal op w		un l
		ce of Technology Management - on a national as we f important elements of Technology Managemen		
	process-related aspects)	important elements of recimology management	i (strategic, operatio	nai, organizational e
		olving within the innovation process as well as Tec	hnology Managemer	nt and its importance
	corporate strategy		0, 0	
		nt (e.g. technology sourcing, maintenance and expl	oitation)	
	Strengthen essential communication skill	ls and a basic understanding of managerial, orga	anizational and fina	ncial issues concern
	Technology-, Innovation- and R&D-manage	ement. Further topics to be discussed include:		
	. Designed and the second tests and the second		- 4 ¹	
		t to the management of technology, R&D and innova	ation	
	 Innovation as a process (steps, activities ar 	ia results)		
Personal Competence				
Social Competence				
	Interact within a team			
	 Raise awareness for globabl issues 			
Autonomy				
	Gain access to knowledge sources			
	 Interpret complicated cases Develop presentation skills 			
	Develop presentation skills			
Workload in Hours	Independent Study Time 110, Study Time in Lectur	re 70		
· · · ·	6			
Credit points	Written exam			
Credit points Examination				
	90 minutes			
Examination		: Compulsory		
Examination Examination duration and scale	Global Innovation Management: Core qualification International Management and Engineering: Spec	ialisation I. Electives Management: Elective Compu	lsory	
Examination Examination duration and scale Assignment for the Following	Global Innovation Management: Core qualification International Management and Engineering: Speci Mechanical Engineering and Management: Specia	ialisation I. Electives Management: Elective Compu alisation Management: Elective Compulsory	·	
Examination Examination duration and scale Assignment for the Following	Global Innovation Management: Core qualification International Management and Engineering: Spec Mechanical Engineering and Management: Specia Biomedical Engineering: Specialisation Artificial O	ialisation I. Electives Management: Elective Compu alisation Management: Elective Compulsory Organs and Regenerative Medicine: Elective Compu	·	
Examination Examination duration and scale Assignment for the Following	Global Innovation Management: Core qualification International Management and Engineering: Speci Mechanical Engineering and Management: Specia Biomedical Engineering: Specialisation Artificial O Biomedical Engineering: Specialisation Implants a	ialisation I. Electives Management: Elective Compu alisation Management: Elective Compulsory Organs and Regenerative Medicine: Elective Compu	lsory	



Course L0849: Technology Manag	ement
Тур	Problem-based Learning
Hrs/wk	3
CP	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 Manag	Course L0850: Technology Management Seminar	
Тур	Problem-based Learning	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Cornelius Herstatt	
Language	EN	
Cycle	WiSe	
Content	Aspects of and Cases in combination with the content of the lecture.	
Literature	see lecture Technology Management.	



Module M0846: Control Sy	stems Theory and Design			
Courses				
Title		Тур	Hrs/wk	CP
Control Systems Theory and Design (LC	656)	Lecture	2	4
Control Systems Theory and Design (LC	657)	Recitation Section (small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	Introduction to Control Systems			
Knowledge	·····			
	After taking part successfully, students have reached th	ne following learning results		
Professional Competence	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
Knowledge				
, no mougo	 Students can explain how linear dynamic system 	ems are represented as state space models; t	hey can interpret the sy	stem response to ini
	states or external excitation as trajectories in st	ate space		
	They can explain the system properties contra-	rollability and observability, and their relation	nship to state feedbac	k and state estimati
	respectively			
	They can explain the significance of a minimal	realisation		
	 They can explain observer-based state feedbal 		and disturbance rejecti	ion
	They can extend all of the above to multi-input			
	 They can explain the z-transform and its relation 			
	 They can explain state space models and trans 			
	They can explain the experimental identification	on of ARX models of dynamic systems, and he	ow the identification pro	blem can be solved
	solving a normal equation			
	They can explain how a state space model can	be constructed from a discrete-time impulse r	esponse	
Skills				
	 Students can transform transfer function model 			
	 They can assess controllability and observabili 			
	 They can design LQG controllers for multivarial 			
	They can carry out a controller design both i	n continuous-time and discrete-time domain,	and decide which is	appropriate for a giv
	sampling rate			
	They can identify transfer function models and			
	They can carry out all these tasks using standa	rd software tools (Matlab Control Toolbox, Sys	stem Identification 1001	oox, Simulink)
Personal Competence				
Social Competence	Students can work in small groups on specific problem	ns to arrive at joint solutions.		
Autonomy	Students can obtain information from provided source	s (lecture notes, software documentation, exp	eriment guides) and us	se it when solving giv
	problems.			
	They can assess their knowledge in weekly on-line tes	sts and thereby control their learning progress		
	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engine	ering: Elective Compulsory		
Curricula	Electrical Engineering: Core qualification: Compulsory	,		
	Energy Systems: Core qualification: Elective Compulse	ory		
	Aircraft Systems Engineering: Specialisation Aircraft S	ystems: Compulsory		
	Computational Science and Engineering: Specialisatio		e Compulsory	
	International Management and Engineering: Specialis			
	International Management and Engineering: Specialis			
	Mechanical Engineering and Management: Specialisa			
	Mechatronics: Core qualification: Compulsory	······································		
	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Implants and I			
	Biomedical Engineering: Specialisation Medical Tech			
			leen	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Compu	ISOTY	
	Biomedical Engineering: Specialisation Management Product Development, Materials and Production: Core		ISOTY	



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

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



Module M0867: Productio	n Planning & Control and Digital Ent	erprise		
Courses				
Title		Тур	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929))	Lecture	2	2
Production Planning and Control (L0930))	Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality Manage	ment		
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the module i	n detail and take a critical position to them.		
Skills	Students are capable of choosing and applying m	odels and methods from the module to industrial pro	blems.	
Personal Competence				
Social Competence	Students can develop joint solutions in mixed tea	ns and present them to others.		
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lectur	e 84		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following	International Management and Engineering: Spec	cialisation II. Product Development and Production: I	Elective Compulsory	
Curricula	Logistics, Infrastructure and Mobility: Specialisation	on Production and Logistics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial C	Organs and Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical	echnology and Control Theory: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Manager	nent and Business Administration: Compulsory		
	Product Development, Materials and Production:	Specialisation Product Development: Elective Comp	ulsory	
	Product Development, Materials and Production:	Specialisation Production: Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisati	on Product Development and Production: Elective C	ompulsory	
	Theoretical Mechanical Engineering: Technical C	omplementary Course: Elective Compulsory		

Course L0932: The Digital Enterpr	ise
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



purse L0929: Production Planning and Control	
	Lecture
Hrs/wk	
CP	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
	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 Plannin	urse 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
CP	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	CP
Electronic Circuits for Medical Applicatio	ns (L0696)	Lecture	2	3
Electronic Circuits for Medical Applicatio	ns (L1056)	Recitation Section (small)	1	2
Electronic Circuits for Medical Applicatio	ns (L1408)	Laboratory Course	1	1
Module Responsible	NN			
Admission Requirements	None			
Recommended Previous	Fundamentals of electrical engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge				
	 Students can explain the basic functionality 	of the information transfer by the central nervous	system	
	 Students are able to explain the build-up of 	an action potential and its propagation along an a	axon	
	Students can exemplify the communication	between neurons and electronic devices		
	Students can describe the special features	of low-noise amplifiers for medical applications		
	 Students can explain the functions of prosth 	neses, e. g. an artificial hand		
	Students are able to discuss the potential a	nd limitations of cochlea implants and artificial eye	es	
01.11				
Skills	Students can calculate the time dependen	t voltage behavior of an action potential		
	Students can give scenarios for further impr	rovement of low-noise and low-power signal acqu	isition.	
	Students can develop the block diagrams of	of prosthetic systems		
	 Students can define the building blocks of e 	electronic systems for an articifial eye.		
Personal Competence Social Competence	background. Students are able to recognize their specific 	n the field of medical electronics in teams togo c limitations, so that they can ask for assistance to ar manner and communicate their results in a w	the right time.	
Autonomy	Students can break down their work in apprStudents can handle the complex data struct	status of their knowledge and to define actions for ropriate work packages and schedule their work ir ctures of bioelectrical experiments without needin anner in all cases and situations of experimental v	n a realistic way. g support.	ecessary.
Workload in Hours	Independent Study Time 124, Study Time in Lectur	e 56		
Credit points	6			
Examination Examination duration and scale	Oral exam 40 min			
		halogy: Elective Compulsory		
Assignment for the Following	Electrical Engineering: Specialisation Medical Tech		uloon	
Curricula	Biomedical Engineering: Specialisation Artificial O		uisory	
	Biomedical Engineering: Specialisation Implants a			
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme			



Course L0696: Electronic Circuits	
	Lecture
Hrs/wk	
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	NN
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 Circuits	Course 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	NN	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	



Course L1408: Electronic Circuits	for Medical Applications
Тур	Laboratory Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	NN
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 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: Continuur	n Mechanics			
Courses				
Title		Тур	Hrs/wk	CP
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534))	Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	Mechanics I			
Knowledge	Mechanics II			
Educational Objectives	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to calcu	ulate the mechanical behavior of materials.		
	The students can set up balance laws and apply basics of d	leformation theory to specific aspects, both	in applied contexts a	as in research contexts.
Personal Competence				
Social Competence	The students are able to present solutions to specialists and	d to develop ideas further.		
Autonomy	The students are able to assess their own strengths and continuum mechanics on their own.	weaknesses and to define tasks themselv	es. They can solve	exercises in the area o
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computational Science and Engineering: Specialisation Sc	ientific Computing: Elective Compulsory		
Curricula				
	Mechanical Engineering and Management: Specialisation I	Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective (Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	d Regenerative Medicine: Elective Compu	lsory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Compulsory	/	
	Biomedical Engineering: Specialisation Management and E	Business Administration: Elective Compulse	ory	
	Product Development, Materials and Production: Core qual			
	Theoretical Mechanical Engineering: Technical Complement	ntary Course: Elective Compulsory		

Course L1533: Continuum Mechanics	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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 Mechanics Exercise	
	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
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: Material M	odeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Swantje Bargmann			
Admission Requirements	None			
Recommended Previous	mechanics I			
Knowledge	mechanics II			
	continuum mechanics			
Educational Objectives	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multidimension	onal consitutive material laws		
Skills	The students can implement their own material laws in fi	nite element codes. In particular, the stu	idents can apply thei	r knowledge to variou
	problems of material science and evaluate the corresponding	ng material models.		
Personal Competence				
Social Competence	The students are able to develop solutions, to present them	to specialists and to develop ideas furthe	r.	
Autonomy	The students are able to assess their own strengths and a continuum mechanics on their own.	veaknesses and to define tasks themsel	ves. They can solve	exercises in the area o
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computational Science and Engineering: Specialisation Sc	ientific Computing: Elective Compulsory		
Curricula	Materials Science: Specialisation Modeling: Elective Comp	ulsory		
	Mechanical Engineering and Management: Specialisation I	Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: Elective Compu	ulsory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technolog	y and Control Theory: Elective Compulsor	ry	
	Biomedical Engineering: Specialisation Management and E	Business Administration: Elective Compute	sory	
	Product Development, Materials and Production: Core qual	fication: Elective Compulsory		

Course L1535: Material Modeling	
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Course L1536: Material Modeling	
Тур	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Swantje Bargmann
Language	DE/EN
Cycle	WiSe
Content	 fundamentals of finite element methods fundamentals of material modeling introduction to numerical implementation of material laws overview of modelling of different classes of materials combination of macroscopic quantities to material microstructure
Literature	D. Raabe: Computational Materials Science, The Simulation of Materials, Microstructures and Properties, Wiley-Vch J. Bonet, R.D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge G. Gottstein., Physical Foundations of Materials Science, Springer



Module M1199: Advanced	Functional Materials			
Module Millos. Advanced				
Courses				
Title		Тур	Hrs/wk	CP
Advanced Functional Materials (L1625)		Lecture	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Fundamentals of Materials Science (I and II)			
Knowledge				
Educational Objectives	After taking part successfully, students have reached	he following learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of a	advanced materials along with their applica	tions in technology, in parti	cular metallic, ceramic
	polymeric, semiconductor, modern composite materia	ls (biomaterials) and nanomaterials.		
Skillo	The students will be able to select material configurat	iona according to the technical needs and	if pagagany to design now	v motoriala considering
Skills	architectural principles from the micro- to the macros			-
	them to select optimum materials combinations deper	•	iew on modern materials s	cience, which enables
Personal Competence				
Social Competence	The students are able to present solutions to specialis	sts and to develop ideas further.		
Autonomy	The students are able to			
	 assess their own strengths and weaknesses. 			
	define tasks independently.			
Workload in Hours	Independent Study Time 152, Study Time in Lecture 2	8		
Credit points				
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	Materials Science: Core qualification: Compulsory			
Curricula	Mechanical Engineering and Management: Specialis	ation Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Orga	ns and Regenerative Medicine: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Management	and Business Administration: Elective Con	npulsory	
	Theoretical Mechanical Engineering: Technical Comp	elementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation N	laterials Science: Elective Compulsory		

Course L1625: Advanced Function	Course L1625: Advanced Functional Materials		
Тур	Lecture		
Hrs/wk	2		
CP	6		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28		
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller		
Language	DE/EN		
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	Wird in der Veranstaltung bekannt gegeben		



ourses				
le		Тур	Hrs/wk	CP
roduction to Biochemistry and Molecu	ılar 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 have	reached the following learning results		
Professional Competence				
Knowledge	The students can			
	describe basic biomolecules;	adad in the DNA.		
	 explain how genetic information is constructed and the connection between DNA 			
	• explain the connection between Div	and proteins,		
Skills	The students can			
	 recognize the importance of melocul 	ar parameters for the course of a disease;		
	describe selected molecular-diagnos			
	 explain the relevance of these proce 			
Personal Competence				
Social Competence	The students can participate in discussions	in research and medicine on a technical level.		
Autonomy	The students can develop understanding of	topics from the course, using technical literature, by	themselves	
hatonomy		topics from the obtailed, using toormout merutare, by		
Workload in Hours	Independent Study Time 62, Study Time in L	Lecture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German prog	gram): Specialisation Mechanical Engineering, Focu	is Biomechanics: Compulso	ory
Curricula	General Engineering Science (German prog	gram): Specialisation Biomedical Engineering: Comp	pulsory	
	General Engineering Science (German prog	gram, 7 semester): Specialisation Biomedical Engine	eering: Compulsory	
		gram, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechanic	s: Compulsory
	Electrical Engineering: Specialisation Medic			
		ram): Specialisation Mechanical Engineering, Focus		ry
		ram): Specialisation Biomedical Engineering: Comp		a 1
		ram, 7 semester): Specialisation Mechanical Engine		s: Compulsory
		ram, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Bio			
	• • •	nagement and Business Administration: Elective Col		
		ficial Organs and Regenerative Medicine: Elective C		
		dical Technology and Control Theory: Elective Comp lants and Endoprostheses: Elective Compulsory	Juisoly	
	Technomathematics: Core qualification: Ele			

Course L0386: Introduction to Biochemistry and Molecular Biology		
Тур	Lecture	
Hrs/wk	2	
CP	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	



Module M1333: BIO I: Imp	lants and Fracture Healing			
Courses				
Title		Тур	Hrs/wk	CP
mplants and Fracture Healing (L0376)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Introduction	on into Anatomie" before attending "Implants and F	racture Healing".	
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways I	how bones heal, and the requirements for their exis	stence.	
	The students can name different treatments for	or the spine and hollow bones under given fracture	morphologies.	
01:11-				
Skills	The students can determine the forces acting	within the human body under quasi-static situation	s under specific assumptio	ns.
Personal Competence				
Social Competence	The students can, in groups, solve basic nume	erical modeling tasks for the calculation of internal	forces.	
A	-			
Autonomy	The students can, in groups, solve basic nume	erical modeling tasks for the calculation of internal	forces.	
Workload in Hours	Independent Study Time 62, Study Time in Le	ecture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German progra	am): Specialisation Mechanical Engineering, Focus	s Biomechanics: Compulso	ory
Curricula	General Engineering Science (German progra	am): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (German progra	am, 7 semester): Specialisation Mechanical Engine	ering, Focus Biomechanic	s: Compulsory
	General Engineering Science (German progra	am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	General Engineering Science (English progra	am): Specialisation Biomedical Engineering: Comp	ulsory	
	General Engineering Science (English progra	am): Specialisation Mechanical Engineering, Focus	Biomechanics: Compulso	ry
	General Engineering Science (English progra	am, 7 semester): Specialisation Mechanical Engine	ering, Focus Biomechanics	s: Compulsory
	General Engineering Science (English progra	am, 7 semester): Specialisation Biomedical Engine	ering: Compulsory	
	Mechanical Engineering: Specialisation Biom	nechanics: Compulsory		
		cial Organs and Regenerative Medicine: Elective C	ompulsory	
		ants and Endoprostheses: Elective Compulsory		
		cal Technology and Control Theory: Elective Comp	ulsory	
		agement and Business Administration: Elective Cor		
	Technomathematics: Specialisation III. Engine		. ,	



Course L0376: Implants and Fract	ure Healing
	Lecture
Hrs/wk	
CP	3
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
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
	 Pelvis (anatomy, biomechanics, fracture treatment) 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				
litle		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and M	lechanics II (Hydrostatics, Kinematics, Dynamics)		
Knowledge				
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
	The students possess an in-depth knowledge reg	arding the derivation of the finite element meth	od and are able to	give an overview of
niio in odgo	theoretical and methodical basis of the method.			give an evenien er
Skills	The students are capable to handle engineering pr	oblems by formulating suitable finite elements, as	sembling the corresp	onding system matric
	and solving the resulting system of equations.			
Personal Competence				
Social Competence	-			
Autonomy	The students are able to independently solve cha	llenging computational problems and develop or	wn finite element ro	utines. Problems can
	identified and the results are critically scrutinized.			
Workload in Hours		56		
Credit points Examination				
Examination duration and scale				
Assignment for the Following	Civil Engineering: Core qualification: Compulsory			
Curricula		ulsorv		
	Aircraft Systems Engineering: Specialisation Aircraft			
	Aircraft Systems Engineering: Specialisation Air Tra			
	Computational Science and Engineering: Specialis			
	International Management and Engineering: Specia			
	International Management and Engineering: Specia		Elective Compulsory	
	Mechatronics: Core qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants ar	nd Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Implants and		sorv	
	Biomedical Engineering: Specialisation Manageme			
	Biomedical Engineering: Specialisation Medical Te Biomedical Engineering: Specialisation Artificial Or			
	Biomodical Engineering. Specialisation Attilicial Of		noory	
	Product Development Materials and Production: Co	are qualification. Compulsory		
	Product Development, Materials and Production: Co			
	Product Development, Materials and Production: Co Technomathematics: Specialisation III. Engineering Technomathematics: Core qualification: Elective Co	Science: Elective Compulsory		



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

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



Module M1342: Polymers				
-				
Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polymers (L		Lecture	2	3 3
Processing and design with polymers (L		Lecture	2	3
Module Responsible				
Admission Requirements	None			
	Basics: chemistry / physics / material science			
Knowledge	After taking part as a sofully at sharts have yough	ed the fellowing learning results		
	After taking part successfully, students have reach	ed the following learning results		
Professional Competence		d de Cara de a construction de l'anna and anna barda		
Knowledge	Students can use the knowledge of plastics an	d define the necessary testing and analysis.		
	They can explain the complex relationships str	ucture-property relationship and		
	the interactions of chemical structure of the	polymers, including to explain neighboring	contexts (e.g. sustai	nability, environmenta
	protection).			
Skills	Students are capable of			
	·			
	- using standardized calculation methods in a	given context to mechanical properties (mod	lulus, strength) to calc	ulate and evaluate th
	different materials.			
	- For mechanical recycling problems selecting	appropriate solutions and sizing example Stif	fness, corrosion resist	ance.
Personal Competence				
Social Competence	Students can			
<u>-</u>				
	- arrive at work results in groups and document	them.		
	- provide appropriate feedback and handle feed	back on their own performance constructively	/.	
Autonomy	 provide appropriate feedback and handle feedback on their own performance constructively. 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 quided by teach	ners.
			g,	
	- assess possible consequences of their profes	ssional activity.		
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
Examination	Written exam			
Examination duration and scale	180 min			
	Materials Science: Specialisation Engineering Ma			
Curricula	Biomedical Engineering: Specialisation Implants a			
	Biomedical Engineering: Specialisation Artificial C			
	Biomedical Engineering: Specialisation Managem			
	Biomedical Engineering: Specialisation Medical T	· · · · ·	sory	
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S		ompulsory	
	Theoretical Mechanical Engineering: Specialisatic	miniaterials Science: Elective Compulsory		



Course L0389: Structure and Prop	erties of Polymers
	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Dr. 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 and de	course L1892: Processing and design with polymers		
Тур	Lecture		
Hrs/wk	2		
CP	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
Bioelectromagnetics: Principles and Apr	lications (L0371)	Lecture	3	5
Bioelectromagnetics: Principles and App		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous	Basic principles of physics			
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	Students can explain the basic principles, rel	ationships, and methods of bioelectromagnetics	s, i.e. the quantificati	ion and application
	electromagnetic fields in biological tissue. They c	an define and exemplify the most important physic	al phenomena and or	der them correspond
	to wavelength and frequency of the fields. The	y can give an overview over measurement and	numerical techniques	for characterization
	electromagnetic fields in practical applications .	They can give examples for therapeutic and diag	gnostic utilization of e	lectromagnetic fields
	medical technology.			
Skills	Students know how to apply various methods to c	haracterize the behavior of electromagnetic fields in	n biological tissue. In	order to do this they
	relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these mode			
	predict for biological tissue, they can order the ef	fects corresponding to wavelength and frequency,	respectively, and they	y can analyze them
	quantitative way. They are able to develop validate	tion strategies for their predictions. They are able to	evaluate the effects of	of electromagnetic fie
	for therapeutic and diagnostic applications and ma	ake an appropriate choice.		
Personal Competence				
Social Competence	Students are able to work together on subject rela	ited tasks in small groups. They are able to presen	t their results effectivel	y in English (e.g. du
	small group exercises).			
Autonomu	Otudente ere conchie to active information from a	which related preferring publications and relation	a that information to th	a contaut of the lock
Autonomy		their knowledge obtained in this lecture with t		
		cal engineering / physics). They can commun		
	bioelectromagnetics in English.	car engineering / physics). They can commun	icate problems and	
Workload in Hours	Independent Study Time 110, Study Time in Lectu	ire 70		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30-60 minutes			
Assignment for the Following	Electrical Engineering: Specialisation Microwave	Engineering, Optics, and Electromagnetic Compati	bility: Elective Compul	sory
Curricula	Electrical Engineering: Specialisation Medical Tec	chnology: Elective Compulsory		
	International Management and Engineering: Spec	cialisation II. Electrical Engineering: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Artificial C	Organs and Regenerative Medicine: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Implants a	and Endoprostheses: Elective Compulsory		
	Diamodical Engineering: Specialization Medical T	a sha sha shu and Cantral Theory (Flasting Compulse	F1 (
		echnology and Control Theory: Elective Compulso nent and Business Administration: Elective Compul		



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	SoSe
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: Bioelectromagnetic	cs: Principles and Applications
Тур	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
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)



Module M1335: BIO II: Artificia	Joint Replacement			
Courses				
ïtle		Тур	Hrs/wk	СР
rtificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible Prof.	lichael Morlock			
Admission Requirements Non				
Recommended Previous				
Knowledge				
Educational Objectives After	king part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours Inde	endent Study Time 62, Study Time in L	Lecture 28		
Credit points 3				
Examination Writt	exam			
Examination duration and scale 90 m				
Assignment for the Following Inter	tional Management and Engineering	: Specialisation II. Process Engineering and Biotechr	ology: Elective Compulsor	У
Curricula Mate	als Science: Specialisation Nano and	Hybrid Materials: Elective Compulsory		
Bion	dical Engineering: Specialisation Artif	ficial Organs and Regenerative Medicine: Elective Co	ompulsory	
Bion	dical Engineering: Specialisation Imp	lants and Endoprostheses: Compulsory		
Bion	dical Engineering: Specialisation Mec	dical Technology and Control Theory: Elective Comp	ulsory	
Bion	dical Engineering: Specialisation Mar	nagement and Business Administration: Elective Com	npulsory	
Theo	tical Mechanical Engineering: Specia	alisation Bio- and Medical Technology: Elective Com	oulsory	
Theo	tical Mechanical Engineering: Techni	ical Complementary Course: Elective Compulsory		

Course L1306: Artificial Joint Repl	lacement
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
	Prof. Michael Morlock
Language	
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)
	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				
		T	Hara faile	0.0
Fitle		Тур	Hrs/wk	CP
Robotics and Navigation in Medicine (LC Robotics and Navigation in Medicine (LC		Lecture Project Seminar	2	3 2
Robotics and Navigation in Medicine (LC		Recitation Section (small)	1	1
	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous				
Knowledge	 principles of math (algebra, analysis/calc 	ulus)		
	 principles of programming, e.g., in Java or 	r C++		
	 solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence		• •		
Knowledge	The students can explain kinematics and trackin	g systems in clinical contexts and illustrate systems	and their components	s in details. Systems o
Ũ		nd safety and regulations. Students can assess typ		-
Skills	The students are able to design and evaluate na	vigation systems and robotic systems for medical ap	plications.	
Personal Competence				
Social Competence	The students discuss the results of other groups,	provide helpful feedback and can incoorporate feed	back into their work.	
Autonomy	The students can reflect their knowledge and de	nument the regulte of their work. They can present the	a regulta in an approp	rioto monnor
Autonomy	The students carrenect their knowledge and dot	cument the results of their work. They can present th	e results in an approp	nale manner.
Workload in Hours	Independent Study Time 110, Study Time in Lect	ture 70		
Credit points	6			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following	Computer Science: Specialisation Intelligence E	ngineering: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical Te	echnology: Elective Compulsory		
	Computational Science and Engineering: Specia	alisation Systems Engineering and Robotics: Elective	e Compulsory	
	International Management and Engineering: Spe	ecialisation II. Electrical Engineering: Elective Comp	ulsory	
	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Compulso	ry	
	Biomedical Engineering: Specialisation Manage	ment and Business Administration: Elective Comput	sory	
	Product Development, Materials and Production:	Specialisation Product Development: Elective Com	pulsory	
	Product Development, Materials and Production:	Specialisation Production: Elective Compulsory		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical (Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisat	tion Rig, and Madical Tashnalagu: Elective Compute	onu	

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



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

Course L0336: Robotics and Navi	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	



on into Medical Technology and Syste	ems		
	Тур	Hrs/wk	СР
d Systems (L0342)	Lecture	2	3
d Systems (L0343)	Project Seminar	2	2
d Systems (L1876)	Recitation Section (large)	1	1
Prof. Alexander Schlaefer			
None			
principles of math (algebra, analysis/calculus)			
principles of stochastics			
principles of programming, R/Matlab			
After taking part successfully, students have reached	d the following learning results		
The students can explain principles of medical tech	nology, including imaging systems, computer aid	ed surgery, and medi	cal information systen
They are able to give an overview of regulatory affai	rs and standards in medical technology.		
The students are able to evaluate systems and med	ical devices in the context of clinical applications.		
The students describe a problem in medical technol	ogy as a project, and define tasks that are solved	in a joint effort.	
The students can reflect their knowledge and docum	nent the results of their work. They can present the	e results in an approp	riate manner.
Independent Study Time 110, Study Time in Lecture	970		
6			
Written exam			
90 minutes			
General Engineering Science (German program): S	pecialisation Biomedical Engineering: Compulso	ry	
General Engineering Science (German program, 7 s	semester): Specialisation Biomedical Engineering	g: Compulsory	
Computer Science: Specialisation Computer and Science	oftware Engineering: Elective Compulsory		
Electrical Engineering: Core qualification: Elective C	Compulsory		
General Engineering Science (English program): Sp	pecialisation Biomedical Engineering: Compulsor	у	
General Engineering Science (English program, 7 s	emester): Specialisation Biomedical Engineering	: Compulsory	
Computational Science and Engineering: Specialisa	ation Computer Science: Elective Compulsory		
Biomedical Engineering: Specialisation Artificial Org	gans and Regenerative Medicine: Elective Compu	ulsory	
Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Elective Compulsory		
		ry	
• • •			
	d Systems (L0342) d Systems (L0343) d Systems (L1876) Prof. Alexander Schlaefer None principles of math (algebra, analysis/calculus) principles of stochastics principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reacher The students can explain principles of medical tech They are able to give an overview of regulatory affai The students are able to evaluate systems and med The students describe a problem in medical technol The students can reflect their knowledge and docun Independent Study Time 110, Study Time in Lecture 6 Written exam 90 minutes General Engineering Science (German program): S General Engineering Science (German program): S General Engineering Science (English program): S General Engineering Science and Engineering: Specialiss Computational Science and Engineering: Specialis Biomedical Engineering: Specialisation Implants an Biomedical Engineering: Specialisation Medical Ter	d Systems (L0342) Lecture d Systems (L1876) Project Seminar d Systems (L1876) Recitation Section (large) Prof. Alexander Schlaefer None Principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab After taking part successfully, students have reached the following learning results The students can explain principles of medical technology, including imaging systems, computer aid They are able to give an overview of regulatory affairs and standards in medical technology. The students are able to evaluate systems and medical devices in the context of clinical applications. The students describe a problem in medical technology as a project, and define tasks that are solved The students can reflect their knowledge and document the results of their work. They can present the Independent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes General Engineering Science (German program): Specialisation Biomedical Engineering: Compulso General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsor General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsor <td>Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Recitation Section (large) 1 Prof. Alexander Schlaefer None Principles of math (algebra, analysis/calculus) 1 principles of math (algebra, analysis/calculus) principles of stochastics 1 principles of stochastics principles of programming, R/Mattab 1 After taking part successfully, students have reached the following learning results 1 The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical technology. 1 The students are able to give an overview of regulatory affairs and standards in medical technology. 1 The students are able to evaluate systems and medical devices in the context of clinical applications. 1 The students can reflect their knowledge and document the results of their work. They can present the results in an appropindent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes 1 General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory 2 Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory 2 General Engineering Science (English p</td>	Typ Hrs/wk d Systems (L0342) Lecture 2 d Systems (L1876) Recitation Section (large) 1 Prof. Alexander Schlaefer None Principles of math (algebra, analysis/calculus) 1 principles of math (algebra, analysis/calculus) principles of stochastics 1 principles of stochastics principles of programming, R/Mattab 1 After taking part successfully, students have reached the following learning results 1 The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical technology. 1 The students are able to give an overview of regulatory affairs and standards in medical technology. 1 The students are able to evaluate systems and medical devices in the context of clinical applications. 1 The students can reflect their knowledge and document the results of their work. They can present the results in an appropindent Study Time 110, Study Time in Lecture 70 6 Written exam 90 minutes 1 General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory 2 Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory 2 General Engineering Science (English p

Course L0342: Introduction into 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 into M	ourse L0343: Introduction into Medical Technology and Systems		
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	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1876: Introduction into Me	ourse L1876: Introduction into Medical Technology and Systems		
Тур	lecitation Section (large)		
Hrs/wk	1		
CP	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.		



Iodule M0752: Nonlinear	Dynamics		
Courses			
litle		Тур	Hrs/wk CP
Nonlinear Dynamics (L0702)		Lecture	4 6
Module Responsible	Prof. Norbert Hoffmann		
Admission Requirements	None		
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics		
Educational Objectives	After taking part successfully, students have read	ched the following learning results	
Professional Competence Knowledge Skills	Students are able to reflect existing terms and co Students are able to apply existing methods and		
Personal Competence	Sudents are able to apply existing methods and	i procesures of Norninear Dynamics and to deve	siop nover methods and procedules.
	Students can reach working results also in group		
Autonomy	Students can reach working results also in group Students are able to approach given research ta		wal research tasks by themselves
Workload in Hours	Independent Study Time 124, Study Time in Lec		vertesearch tasks by themselves.
Credit points			
Examination	Written exam		
Examination duration and scale			
		areft Sustamer Flactive Compulsory	
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Air Computational Science and Engineering: Specia		lson/
Curricula	International Management and Engineering: Specific		•
	Mechanical Engineering and Management: Spe		
	Mechatronics: Specialisation System Design: El		
	Mechatronics: Specialisation Intelligent Systems		
	Biomedical Engineering: Specialisation Artificial		Compulsory
	Biomedical Engineering: Specialisation Implants	• •	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Com	pulsory
	Biomedical Engineering: Specialisation Manage	ement and Business Administration: Elective Co	mpulsory
	Product Development, Materials and Production	: Core qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical	Complementary Course: Elective Compulsory	
	Theoretical Mechanical Engineering: Core quali	Fastion Flastice Osmanlase	

Course L0702: Nonlinear Dynamic	Course L0702: Nonlinear Dynamics	
Тур	Lecture	
Hrs/wk	4	
CP	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	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	5
Semiconductor Technology (L0723)		Laboratory Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements				
Recommended Previous	Basics in physics, chemistry, material science and semicono	luctor devices		
Knowledge	After taking part successfully, students have reached the foll	awing loorning rooulto		
Educational Objectives Professional Competence	Alter taking part successiony, students have reached the foli	Dwing learning results		
Knowledge				
Knowledge				
	Students are able			
	to describe and to explain current fabrication techniques	for Si and GaAs substrates,		
	• to discuss in details the relevant fabrication processes,	process flows and the impact thereof o	n the fabrication of sem	niconductor devices ar
	integrated circuits and			
	to present integrated process flows.			
01:11-				
Skills				
	Students are capable			
	 to analyze the impact of process parameters on the proc 	essing results,		
	to select and to evaluate processes and			
	 to develop process flows for the fabrication of semicondu 	ctor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab experime	nts in team work as well as to present a	nd discuss the results i	n front of audience.
Autonomy	None			
Workload in Hours	Independent Study Time 126, Study Time in Lecture 84			
Credit points	7			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Nanoelectronics and	Microsystems Technology: Elective Con	npulsory	
Curricula	Biomedical Engineering: Specialisation Artificial Organs and	•	pulsory	
	Biomedical Engineering: Specialisation Implants and Endop			
	Biomedical Engineering: Specialisation Medical Technology Biomedical Engineering: Specialisation Management and B	•	•	



Course L0722: Semiconductor Teo	chnology
Тур	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, 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, 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, kinetics, 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 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: excimer laser light source, immersion lithography and phase shift lithography, electro beam lithography, X-ray lithography, EUV lithography, 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 pro
Literature	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: Semiconductor Tee	urse L0723: Semiconductor Technology		
Тур	Laboratory 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: Humanoid	Robotics			
Courses				
Title Humanoid Robotics (L0663)		Typ Seminar	Hrs/wk	CP 2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				-
Knowledge				
	Students can explain humanoid robots.Students learn to apply basic control concepts for	r different tasks in humanoid rebeties		
	 Students learn to apply basic control concepts to 			
Skills	 Students acquire knowledge about selected aspected. 	ects of humanoid robotics, based on spo	ecified literature	
	 Students dequire intermedge about oncoded apple Students generalize developed results and prese 			
	 Students practice to prepare and give a presenta 			
Personal Competence				
Social Competence	 Students are capable of developing solutions in i 	nterdisciplinary teams and present ther	n	
	They are able to provide appropriate feedback as			
Autonomy	 Students evaluate advantages and drawbacks of 	different forms of presentation for spec	ific tasks and select the best	solution
	 Students familiarize themselves with a scientifi 			
	scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control and Powe	r Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Systems and Ro	botics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management ar		mpulsory	
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Core qualification:	Elective Compulsory		

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



Courses				
Title		Тур	Hrs/wk	СР
inear and Nonlinear System Identificati	on (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response, ro State space methods	oot locus)		
	State space methodsDiscrete-time systems			
	 Discrete-time systems Linear algebra, singular value decomposition 	sition		
	Basic knowledge about stochastic proces			
		5555		
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	 Students can explain the general frame; 	work of the prediction error method and its app	lication to a variety of line	ar and nonlinear mo
	structures		silication to a variety of line	ar and nonintear mo
		ron networks are used to model nonlinear dyna	mics	
		redictive control scheme can be based on neura		
		lentification and its relation to Kalman realisatio		
Skills	 Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for 		near models for dynai	
	systems			
	 They are capable of implementing a non 	linear predictive control scheme based on a ner	ural network model	
	They are capable of applying subspace a	algorithms to the experimental identification of li	near models for dynamic s	ystems
	They can do the above using standard so	oftware tools (including the Matlab System Ident	ification Toolbox)	
Personal Competence				
Social Competence	Students can work in mixed groups on specific p	roblems to arrive at joint solutions.		
			6 I I I I I I I I I I I I I I I I I I I	
Autonomy	Students are able to find required information i problems.	in sources provided (lecture notes, interature, s	sonware documentation) a	nd use it to solve giv
	problems.			
Workload in Hours	Independent Study Time 62, Study Time in Lectu	ıre 28		
Credit points	3			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Electrical Engineering: Specialisation Control ar	nd Power Systems: Elective Compulsory		
Curricula	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation Artificial	• •	Compulsory	
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical			
	Biomedical Engineering: Specialisation Manage		mpulsory	
	Theoretical Mechanical Engineering: Technical Theoretical Mechanical Engineering: Core quali			

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



Courses				
litle		Tur	Hrs/wk	СР
Dptimal and Robust Control (L0658)		Typ Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response, root locus)		
	State space methods			
	Linear algebra, singular value decomposition			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge				
	Students can explain the significance of the matri		ems.	
	 They can explain the duality between optimal sta They can explain how the H2 and H-infinity norm 			
	 They can explain how an LQG design problem ca 			
	 They can explain how an Equilation of the second sec		•	
	 They can explain how - based on the small gain 		-	mance for an unce
	plant.	-		
	They understand how analysis and synthesis cor	iditions on feedback loops can be represented	l as linear matrix ine	qualities.
Skills	Students are capable of designing and tuning LC	G controllers for multivariable plant models.		
	They are capable of representing a H2 or H-infin	ity design problem in the form of a generalized	d plant, and of using	standard software t
	for solving it.			
	They are capable of translating time and frequ	ency domain specifications for control loops	into constraints on	closed-loop sensi
	functions, and of carrying out a mixed-sensitivity	design.		
	 They are capable of constructing an LFT uncertain 			
	They are capable of formulating analysis and syr	othesis conditions as linear matrix inequalities	(LMI), and of using :	standard LMI-solver
	solving them.			
	 They can carry out all of the above using standar 	a software tools (Matiab robust control toolbox).	
Personal Competence				
Social Competence	e Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	y Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve g			
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineer	• • •		
Curricula	Electrical Engineering: Specialisation Control and Powe			
	Energy Systems: Core qualification: Elective Compulsor			
	Aircraft Systems Engineering: Specialisation Aircraft Sys		0	
	Computational Science and Engineering: Specialisation		Jompulsory	
	Mechatronics: Specialisation Intelligent Systems and Ro Mechatronics: Specialisation System Design: Elective Co			
	Biomedical Engineering: Specialisation Artificial Organs		sorv	
	Biomedical Engineering: Specialisation Implants and En	-		
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management an			
	Product Development, Materials and Production: Specia			
	Product Development, Materials and Production: Specia		-	
	Product Development, Materials and Production: Specia	lisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complete	mentary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core qualification:			



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

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



Courses				
Title		Тур	Hrs/wk	CP
Feedback Control in Medical Technolog	y (L0664)	Lecture	2	3
Module Responsible	Prof. Olaf Simanski			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge	The lecture will introduce into the fascinating	area of medical technology with the engineering	point of view. Fundamenta	als in human physiolo
	will be similarly introduced like knowledge in c	ontrol theory.		
	Internal control loops of the human body will	be discussed in the same way like the design	of external closed loop s	stem to example in t
	anesthesia control.			
	, , , , , , , , , , , , , , , , , , ,	controller like predictive controller or fuzzy cor	ntroller or neural networks	will be illustrated. T
	operation of simple equivalent circuits will be o	liscussed.		
Skills	Application of modeling, identification, control	technology in the field of medical technology.		
Personal Competence				
Social Competence	Students can develop solutions to specific prol	plems in small groups and present their results (e	.g. during project week)	
A	Objelanda and able to final management literature	and the section into the second state of the design of the second state of the second		
Autonomy		and to set it into the context of the lecture. They ney can combine knowledge from different course		
	and to take control of their learning process. In	ley can combine knowledge from different course		J.
Workload in Hours	Independent Study Time 62, Study Time in Leo	cture 28		
Credit points	3			
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following	Electrical Engineering: Specialisation Control	and Power Systems: Elective Compulsory		
Curricula	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory		
	Biomedical Engineering: Specialisation Artifici	al Organs and Regenerative Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Implan	nts and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Compulsory		
	Biomedical Engineering: Specialisation Manag	nement and Business Administration: Elective Cou	mpulsory	

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



Irses				
1303		Тур	Hrs/wk	CP
eting (Innovation Marketing / Sales	and Services) (L0862)	۲۷۲ Problem-based Learning	5	6
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous				
Knowledge	Module International Business			
	 Basic understanding of business administrati business) 	on principles (strategic planning, decision t	neory, project mai	lagement, interna
	 Bachelor-level Marketing Knowledge (Marketing 	Instruments, Market and Competitor Strategies	, Basics of Buying E	Behavior)
	 Understanding of differences in the market introd 		,	,
	Unerstanding the differences beweetn B2B and			
	 Understanding of the importance of managing in 	novation 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 innov			
	 The importance of product-related and independent Approaches for analyzing the current market situation 			
	 The gathering of information about future custom 			
	 Concepts and approaches to integrate lead user 		lopment processes	5
	 Approaches and tools for ensuring customer-original c			
	Marketing mix elements that take into considerat	ion the specific requirements and challenges of	innovative product	s and services
	Pricing methods for new products and services			
	The organization of complex sales forces and per	ersonal selling		
	 Communication concepts and instruments for ne 	w products and services		
Skills	Based on the acquired knowledge students will be able	to:		
	 Design and to evaluate decisions regarding mar 	kating and innovation stratogies		
	 Analyze markets by applying market and technol 			
	 Conduct forecasts and develop compelling scen 			
	Translate customer needs into concepts, proto		y apply advanced	methods for custo
	oriented product and service development			
	Use adequate methods to foster efficient diffusio	n of innovative products and services		
	Choose suitable pricing strategies and communi	cation 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. of the sale of	customer value analysis)		
Personal Competence				
Social Competence	The students will be able to			
	 boyo fruitful discussions and such such as a 	to		
	 have fruitful discussions and exchange argumer develop original results in a group 	115		
	 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	,	w complex problem	n fields.
	Consider proposed business actions in the field	or marketing and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Examination	Written exam			
amination duration and scale	90 min			
Assignment for the Following	International Management and Engineering: Specialisa	tion I. Electives Management: Elective Compuls	ory	
Curricula	Mechanical Engineering and Management: Specialisati	on Management: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs		sory	
	Biomedical Engineering: Specialisation Implants and Er			
	Biomedical Engineering: Specialisation Medical Techno			



	ion Marketing / Sales and Services)
Тур	Problem-based Learning
Hrs/wk CP	5 6
Workload in Hours	ndependent Study Time 110, Study Time in Lecture 70
Lecturer	Prof. Christian Lüthje
Language	
Cycle	SoSe
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. Mapping Techniques
	Perceptual Maps, Gap Model
	V. User innovations
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	VI. 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
	XI. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Kotler, P., Keller, K. L. (2006). Marketing Management, 12 th edition, Pearson Prentice Hall, New Jersey
	Bo Edvardsson et. al. (2006) Involving Customers in New Service Development, London
	Joe Tidd & Frank M. Hull (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008



Module M1143: Mechanic	al Design Methodology			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Design Methodology (L1523	3)	Lecture	3	4
Mechanical Design Methodology (L1524	ł)	Recitation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have n	eached the following learning results		
Professional Competence				
Knowledge	Science-based working on product design co	onsidering targeted application of specific product desig	gn techniques	
Skills	5 1	ntific preparation and formulation of complex product d	esign problems / Appli	cation of various produ
	design techniques following theoretical aspe	cts.		
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in	_ecture 56		
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	International Management and Engineering:	Specialisation II. Product Development and Production	: Elective Compulsory	
Curricula	Mechatronics: Specialisation System Design	Elective Compulsory		
	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Med	ical Technology and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Man	agement and Business Administration: Elective Compu	Ilsory	
	Product Development, Materials and Product	ion: Specialisation Product Development: Elective Cor	npulsory	
	Product Development, Materials and Product	ion: Specialisation Production: Elective Compulsory		
	Product Development, Materials and Product	ion: Specialisation Materials: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	isation Product Development and Production: Elective	Compulsory	
	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulsory		

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



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



Courses				
litle		Тур	Hrs/wk	CP
Bioprocess Engineering - Fundamentals	(L0841)	Lecture	2	3
Bioprocess Engineering- Fundamentals		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental F	Practical Course (L0843)	Laboratory Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "fundamer	ntals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students are able to describe the basic concepts of	bioprocess engineering. They are able to classif	y different types of k	kinetics for enzymes
	microorganisms, as well as to differentiate different	types of inhibition. The parameters of stoichiom	etry and rheology c	an be named and m
	transport processes in bioreactors can be explaine	d. The students are capable to explain fundam	ental bioprocess m	anagement, steriliza
	technology and downstream processing in detail.			
o				
Skills	After successful completion of this module, students s	hould be able to		
	 describe different kinetic approaches for grow 	th and substrate-uptake and to calculate the corre	esponding paramete	ers
	 predict qualitatively the influence of energy 	generation, regeneration of redox equivalents	and growth inhibit	ion on the fermenta
	process			
	 analyze bioprocesses on basis of stoichiomet 	ry and to set up / solve metabolic flux equations		
	distinguish between scale-up criteria for diffe	rent bioreactors and bioprocesses (anaerobic, a	erobic as well as m	icroaerobic) to comp
	them as well as to apply them to current bioted	chnical problem		
	 propose solutions to complicated biotechnology 	gical problems and to deduce the corresponding	models	
	• to evolute new knowledge resources and to a	poly the newly acided contents		
	 to explore new knowledge resources and to a identify scientific problems with concrete indust 			
	 to document and discuss their procedures as 			
	• to document and discuss their procedures as			
Personal Competence				
-	After completion of this module participants should b	e able to debate technical questions in small tea	ms to enhance the	ability to take positio
oocial competence	their own opinions and increase their capacity for tea			ability to take positio
	alon own opinions and morease alon oupdoby for tea			
Autonomy	After completion of this module participants will be at	ble to solve a technical problem in a team indepe	ndently by organizi	ng their workflow and
	present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84	1		
Credit points	6			
Examination				
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): Sp	0 0 1 7		
Curricula	General Engineering Science (German program): Sp			
	General Engineering Science (German program, 7 se			
	General Engineering Science (German program, 7 se	, , , , , , , , , , , , , , , , , , , ,	Compulsory	
	Bioprocess Engineering: Core qualification: Compuls	•		
	General Engineering Science (English program): Spe			
	General Engineering Science (English program): Spe			
	General Engineering Science (English program, 7 se			
	General Engineering Science (English program, 7 se		Compulsory	
	Biomedical Engineering: Specialisation Artificial Orga	• • • •		
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech			
	Biomedical Engineering: Specialisation Management		ory	
	Technomathematics: Specialisation III. Engineering S			
	Process Engineering: Core qualification: Compulsory			



Course L0841: Bioprocess Engine	ering - 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) Technology of sterilization (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 Engine	Course L0842: Bioprocess Engineering- Fundamentals	
Тур	Recitation Section (large)	
Hrs/wk	2	
CP	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 Engine	ering - Fundamental Practical Course
Тур	Laboratory Course
Hrs/wk	2
CP	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



Module M1277: MED I: Intr	roduction to Anatomy			
Courses				
Title	Typ Hrs/wk CP			
Introduction to Anatomy (L0384)	Lecture 2 3			
Module Responsible	Prof. Udo Schumacher			
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 basal structures and functions of internal organs and the musculoskeletal system.			
	The students can describe the basic macroscopy and microscopy of those systems.			
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can expla			
	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 acquire the relevant			
	knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points				
Examination				
Examination duration and scale				
Assignment for the Following	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory			
Curricula	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory			
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory			
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory			
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory			
	General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory			
	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory			
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: 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 implants and Endoprositieses: Elective Compulsory			
	Teomoniauroniauco. opedialisation ili. Engineening Science. Elective Collipuisolly			



Typ	Lecture			
Hrs/wk				
CP				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Tobias Lange			
Language				
Cycle				
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			
	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/Michael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag Stuttgart, 2012			



Courses		-			
Title ntroduction to Radiology and Radiation	Therapy (L0383)	Typ Lecture	Hrs/wk 2	СР 3	
Module Responsible	Prof. Ulrich Carl		_	-	
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successfully, students have reache	d the following learning results			
Professional Competence					
Knowledge	Therapy The students can distinguish different types of curre	ntly used equipment with respect to its use ir	n radiation therapy.		
	The students can explain treatment plans used in ra	adiation therapy in interdisciplinary contexts (e.g. surgery, internal medic	sine).	
	The students can describe the patients' passage	from their initial admittance through to foll	ow-up care.		
	Diagnostics				
	The students can illustrate the technical base conc imaging techniques (CT, MRT, US).	epts of projection radiography, including ang	jiography and mammograp	hy, as well as section	
	The students can explain the diagnostic as well as	herapeutic use of imaging techniques, as we	ell as the technical basis for	those techniques.	
	The students can choose the right treatment method	d depending on the patient's clinical history a	nd needs.		
	The student can explain the influence of technical e	rrors on the imaging techniques.			
	The student can draw the right conclusions based of	n the images' diagnostic findings or the error	r protocol.		
Skills	Therapy The students can distinguish curative and palliative	situations and motivate why they came to the	at conclusion.		
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.				
	The students can use the therapeutic principle (effe	cts vs adverse effects)			
	The students can distinguish different kinds of radi the energy needed in that situation (irradiation plan		on the situation (location of	the tumor) and choo	
	The student can assess what an individual psycho groups, social services, psycho-oncology).	osocial service should look like (e.g. follow-	up treatment, sports, socia	l help groups, self-h	
	Diagnostics				
	The students can suggest solutions for repairs of im	aging instrumentation after having done erro	or analyses.		
	The students can classify results of imaging technic and pathophysiology.	ues according to different groups of disease	s based on their knowledg	e of anatomy, patholo	
Personal Competence					
Social Competence	The students can assess the special social situation The students are aware of the special, often fear-do them appropriately.			neasures and can m	
Autonomy	11,5				
	The students can introduce younger students to the				
	The students are able to access anatomical knowle relevant knowledge themselves.	edge by themselves, can participate compete	ently in conversations on tr	ie topic and acquire i	
Workload in Hours	Independent Study Time 62, Study Time in Lecture	28			
Credit points	3				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	General Engineering Science (German program): S			ary	
Curricula	General Engineering Science (German program): S General Engineering Science (German program, 7				
	General Engineering Science (German program, 7	, , ,		s: Compulsory	
	Electrical Engineering: Specialisation Medical Tech				
	General Engineering Science (English program): S			ry	
	General Engineering Science (English program): S General Engineering Science (English program, 7 s			s: Compulsory	
	General Engineering Science (English program, 7 s		-	. sompulaory	
	Mechanical Engineering: Specialisation Biomechan	, ,	- · ·		
	Biomedical Engineering: Specialisation Medical Te Biomedical Engineering: Specialisation Manageme				
			1 · · · · 2		

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 TUHH

Course L0383: Introduction to Rac	liology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	
Lecturer Language	Prof. Ulrich Carl, Prof. Thomas Vestring DE
	SoSe
	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				
		Ture	Huebule	<u></u>
Title Introduction to Physiology (L0385)		Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Dr. Roger Zimmermann	Lecture	L	5
Admission Requirements	None			
Recommended Previous	None			
Knowledge	None			
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence	siter taking part bubbebbility, stadents have rec			
Knowledge	The students can			
Kilowicago				
	 describe the basics of the energy metable 	oolism;		
	 describe physiological relations in selection 	cted fields of muscle, heart/circulation, neuro- and	d sensory physiology.	
Skills	The students can describe the effects of basic	bodily functions (sensory, transmission and pro	ocessing of information, de	velopment of forces a
<i>chino</i>	vital functions) and relate them to similar techni			
Personal Competence				
Social Competence	The students can conduct discussions in resea	rch and medicine on a technical level.		
,	The students can find solutions to problems in t	he field of physiology, both analytical and metrol	logical.	
			-	
Autonomy	The students can derive answers to questions a	arising in the course and other physiological area	as, using technical literatur	e, by themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lec	ture 28		
Credit points	3			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following	General Engineering Science (German program	n): Specialisation Mechanical Engineering, Focu	us Biomechanics: Compuls	ory
Curricula		n): Specialisation Biomedical Engineering: Com		
	General Engineering Science (German program	n, 7 semester): Specialisation Biomedical Engin	eering: Compulsory	
	General Engineering Science (German program	n, 7 semester): Specialisation Mechanical Engin	eering, Focus Biomechani	cs: Compulsory
	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory		
	General Engineering Science (English program	n): Specialisation Mechanical Engineering, Focu	s Biomechanics: Compulso	bry
	General Engineering Science (English program	n): Specialisation Biomedical Engineering: Comp	oulsory	
	General Engineering Science (English program	n, 7 semester): Specialisation Mechanical Engine	eering, Focus Biomechanic	s: Compulsory
	General Engineering Science (English program	n, 7 semester): Specialisation Biomedical Engine	eering: Compulsory	
	Mechanical Engineering: Specialisation Biome	chanics: Compulsory		
	Biomedical Engineering: Specialisation Medica	al Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Manag	ement and Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artificia	al Organs and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implan	ts and Endoprostheses: Elective Compulsory		
	Technomathematics: Core qualification: Electiv	e Compulsory		
	Technomathematics: Specialisation III. Enginee	aring Science: Elective Compulsory		

Course L0385: Introduction to Phy	siology
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Roger Zimmermann
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	CP
Experimental Methods in Biomechanics	(L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implantate und F	rakturheilung" before attending "Experime	ntelle 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 bo	nes heal, and the requirements for their ex	distence.	
	The students can name different treatments for the s	pine and hollow bones under given fracture	e morphologies.	
	The students can describe different measurement te	abniques for foress and maxaments, and a	hadde the adaguate technique	o for a given took
	The students can describe diletent measurement te	childres for forces and movements, and c	noose the adequate techniqu	ie ior a given task.
Skills	The students can describe the basic handling of sev	eral experimental techniques used in biom	echanics.	
Deve and Commetance				
Personal Competence Social Competence	The students can, in groups, solve basic experiment			
Social Competence	The students can, in groups, solve basic experiment	ai lasks.		
Autonomy	The students can, in groups, solve basic experiment	al tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8		
Credit points	3	5		
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following	General Engineering Science (German program): Sp	occiplication Mochanical Engineering For	us Biomochanics: Compulsor	2/
Curricula	General Engineering Science (German program): Sp			у
ourroua	General Engineering Science (German program, 7 s	• •		: Compulsory
	General Engineering Science (German program, 7 s			in e empareer j
	General Engineering Science (English program): Sp	, ,		
	General Engineering Science (English program): Sp	• •		v
	General Engineering Science (English program, 7 s	• •		
	General Engineering Science (English program, 7 s	, , , , , , , , , , , , , , , , , , , ,		
	Mechanical Engineering: Specialisation Biomechan	, ,	compared y	
	Biomedical Engineering: Specialisation Artificial Org		Compulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tec		noulsory	
	Biomedical Engineering: Specialisation Managemen			
	Technomathematics: Specialisation III. Engineering			

Course L0377: Experimental Meth	ods 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



Courses				
Title		Тур	Hrs/wk	CP
Practical Course Introduction to Cell Cul	ture (L0350)	Laboratory Course	3	3
Regenerative Medicine (L0347)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous	For the "Practical course Introduction to cell culture" particip	pation in lecture "Regenerative medicine"	,	
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	After successful completion of the module students will be	able to describe the basic methods of re	egenerative medicine a	nd to explain the use
	the tissue cells for different methods of tissue engineering	g. They are able to give a basic overvie	w of methods for the c	ultivation of animal an
	human cells.			
Skills	After successful completion of the module students are			
	 able to use medical databases for acquirierung and 		independently	
	 able to present their work results in the form of pres 			
	able to carry out basic cell culture methods and the corresponding analysis independently			
Personal Competence				
Social Competence	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			and to defend them.
	Students are able to reflect their work orally and discuss it w	with other students and teachers.		
Autonomy				
	After completion of this module, participants will be able to	solve a technical problem in teams of	approx. 2-4 persons inc	lependently including
	presentation of the results.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6 Descentation			
Examination Examination duration and scale	Presentation	in		
Assignment for the Following	Oral presentation + discussion (30 min) + protocol internsh Biomedical Engineering: Specialisation Artificial Organs ar	•		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Biomedical Engineering: Specialisation Implants and Endo	• • • •		
Curricula	Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technolog		on/	
	Diomedical Engineering. Specialisation Medical Technolog	y and Control Theory: Elective Compuls	ury	

Course L0350: Practical Course In	troduction to Cell Culture
Тур	Laboratory Course
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner
Language	DE
Cycle	SoSe
Content	Introduction to basic skills for cultivation of mammalian cells
	compact practical course
Literature	
	Lindl, T. und Gstraunthaler, G.: Zell- und Gewebekultur. Von den Grundlagen zur Laborbank. Spektrum Akademischer Verlag; 6. Auflage 2008.



Course L0347: Regenerative Med	
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE/EN
Cycle	SoSe
Content	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), Jörr Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540



Courses				
Title		Тур	Hrs/wk	CP
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 m	natrix inequalities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	 Otudents can evaluate the educaterized and shortcome. 	since of the close is a local set of the close of the	a a b	
	 Students can explain the advantages and shortcom They can explain the representation of nonlinear sy 		1011	
	 They can explain the representation of nonlinear sy They can explain how stability and performance co 		as I MI conditions	
	 They can explain now stability and penomance co They can explain how gridding techniques can be it 			
	 They are familiar with polytopic and LFT representation 			es associated with ea
	of these model structures	ations of Er V systems and some of the basic	, synthesis teeninque	
	of these model structures			
	Otudente con evaluin heur granh theoretic concenter			t avatama
	 Students can explain how graph theoretic concepts They can explain the convergence properties of fire 		pology of multiagen	systems
	They can explain the convergence properties of first They can explain analyzic and synthesis conditions		Ther I BV agent me	dolo
	They can explain analysis and synthesis conditions	s for formation control loops involving either i	LITOT LPV agent mo	ueis
	. Otudente con evalein the state energy representation	tation of anoticilly investorst distributed available	tama that are diaar.	stimed according to
	Students can explain the state space represent	ation of spatially invariant distributed syst	tems that are discre	etized according to
	 actuator/sensor array They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions 			
		ounded real lemma to such distributed syste	ims and the associat	ed synthesis conditio
	for distributed controllers			
Skills				
	 Students are capable of constructing LPV mode 		nixed-sensitivity des	sign of gain-schedul
	controllers; they can do this using polytopic, LFT or general LPV models			
	They are able to use standard software tools (Matla	b robust control toolbox) for these tasks		
	Students are able to design distributed formation	controllers for groups of agents with eithe	r LTI or LPV dynam	nics, using Matlab too
	provided			
	Students are able to design distributed controllers f	or spatially interconnected systems, using th	e Matlab MD-toolbo	x
Personal Competence				
Social Competence	Students can work in small groups and arrive at joint result	iS.		
Autonomy	Students are able to find required information in sources	provided (lecture notes, literature, software	e documentation) ar	nd use it to solve giv
	problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following	Computer Science: Specialisation Intelligence Engineering	g: Elective Compulsory		
	Electrical Engineering: Specialisation Control and Power S			
	Electrical Engineering: Specialisation Control and Power S			
	Aircraft Systems Engineering: Specialisation Aircraft System			
			Compulsory	
	Computational Science and Engineering: Specialisation S	,		
	Computational Science and Engineering: Specialisation S International Management and Engineering: Specialisation	n II. Mechatronics: Elective Compulsory		
	International Management and Engineering: Specialisation			
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com	npulsory		
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo	npulsory otics: Elective Compulsory		
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo	npulsory otics: Elective Compulsory oprostheses: Elective Compulsory	son	
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Artificial Organs and	npulsory ptics: Elective Compulsory oprostheses: Elective Compulsory nd Regenerative Medicine: Elective Compuls		
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Artificial Organs ar Biomedical Engineering: Specialisation Management and	npulsory ptics: Elective Compulsory pprostheses: Elective Compulsory nd Regenerative Medicine: Elective Compulso Business Administration: Elective Compulso	ory	
	International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Artificial Organs and	npulsory otics: Elective Compulsory oprostheses: Elective Compulsory nd Regenerative Medicine: Elective Compulso Business Administration: Elective Compulsory gy and Control Theory: Elective Compulsory	ory	



Тур	Lecture	
Hrs/wk	2	
CP	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
	EN	
Cycle		
Content		
	Linear Parameter-Varying (LPV) Gain Scheduling	
	- Linearizing gain scheduling, hidden coupling	
	- Jacobian linearization vs. quasi-LPV models	
	- Stability and induced L2 norm of LPV systems	
	- Synthesis of LPV controllers based on the two-sided projection lemma	
	- Simplifications: controller synthesis for polytopic and LFT models	
	- Experimental identification of LPV models	
	- Controller synthesis based on input/output models	
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator	
	Control of Multi-Agent Systems	
	- Communication graphs	
	- Spectral properties of the graph Laplacian	
	- First and second order consensus protocols	
	- Formation control, stability and performance	
	- LPV models for agents subject to nonholonomic constraints	
	- Application: formation control for a team of quadrotor helicopters	
	Control of Spatially Interconnected Systems	
	- Multidimensional signals, I2 and L2 signal norm	
	- Multidimensional systems in Roesser state space form	
	- Extension of real-bounded lemma to spatially interconnected systems	
	- LMI-based synthesis of distributed controllers	
	- Spatial LPV control of spatially varying systems	
	- Applications: control of temperature profiles, vibration damping for an actuated beam	
Literature		
	Werner, H., Lecture Notes "Advanced Topics in Control"	

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



Module M1227: Lecture Tissue Engineering - Regenerative Medicine				
Courses				
Title		Тур	Hrs/wk	СР
Lecture Tissue Engineering - Regeneral	tive Medicine (L1664)	Seminar	2	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follo	wing learning results		
Professional Competence				
Knowledge	After successful completion of the module students can out explain the basic udnerlying principles of the discussed topic		e Engineering and regenerat	ive medicine and car
Skills	After successful completion of the module students will be regenerative medicine.	able to to analyse and evaluate	current research topics for Tis	ssue Engineering and
Personal Competence				
Social Competence	Students are able to work together as a team with several stu	dents to solve given tasks and dis	cuss their results in the plenar	y and to defend them.
Autonomy	The students are able to present independently the results of their subtasks in a presentation			
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28			
Credit points	6			
Examination	Written elaboration			
Examination duration and scale	written report (10 pages)			
Assignment for the Following	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Compuls	sory	
Curricula	Biomedical Engineering: Specialisation Implants and Endopr	ostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Corr	npulsory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective Co	ompulsory	

Course L1664: Lecture Tissue Engineering - Regenerative Medicine		
Тур	Seminar	
Hrs/wk	2	
CP	6	
Workload in Hours	Independent Study Time 152, 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	



Thesis

Module M-002: Master The	
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	According to General Regulations §24 (1):
	At least 79 availt points have to be achieved in study programme. The examinations heard desides an examinations
	At least 78 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 curre
	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.
Skille	The students are able:
SKIIIS	
	• 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 incomplete
	defined problems in a solution-oriented way.
	 To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can
	Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way.
	 Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholdir
	their own assessments and viewpoints convincingly.
Autonomy	Students are able:
	 To structure a project of their own in work packages and to work them off accordingly.
	 To work their way in depth into a largely unknown subject and to access the information required for them to do so.
	 To apply the techniques of scientific work comprehensively in research of their own.
	Independent Study Time 900, Study Time in Lecture 0
Credit points	
	according to Subject Specific Regulations see FSPO
Examination duration and scale	
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory
Carriolla	Chemical and Bioprocess Engineering: Thesis: Compulsory
	Computer Science: Thesis: Compulsory
	Electrical Engineering: Thesis: Compulsory
	Energy and Environmental Engineering: Thesis: Compulsory
	Energy Systems: Thesis: Compulsory
	Environmental Engineering: Thesis: Compulsory
	Aircraft Systems Engineering: Thesis: Compulsory
	Global Innovation Management: Thesis: Compulsory Computational Science and Engineering: Thesis: Compulsory
	Information and Communication Systems: Thesis: Compulsory
	International Production Management: Thesis: Compulsory
	International Management and Engineering: Thesis: Compulsory
	Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory
	Logistics, Infrastructure and Mobility: Thesis: Compulsory
	Materials Science: Thesis: Compulsory
	Mechanical Engineering and Management: Thesis: Compulsory
	Mechatronics: Thesis: Compulsory
	Biomedical Engineering: Thesis: Compulsory
	Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory
	Renewable Energies: Thesis: Compulsory
	Naval Architecture and Ocean Engineering: Thesis: Compulsory



Ship and Offshore Technology: Thesis: Compulsory
Theoretical Mechanical Engineering: Thesis: Compulsory
Process Engineering: Thesis: Compulsory
Water and Environmental Engineering: Thesis: Compulsory