

# Module Manual

Master of Science (M.Sc.)

# **Biomedical Engineering**

Cohort: Winter Term 2019

Updated: 27th April 2019

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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: B	Business & Management
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	<ul> <li>Students are able to find their way around selected special areas of management within the scope of business management.</li> <li>Students are able to explain basic theories, categories, and models in selected special areas of business management.</li> <li>Students are able to interrelate technical and management knowledge.</li> </ul>
Skills	<ul> <li>Students are able to apply basic methods in selected areas of business management.</li> <li>Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.</li> </ul>
Personal Competence	
Social Competence	<ul> <li>Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems</li> </ul>
Autonomy	<ul> <li>Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.</li> </ul>
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 Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
	The Nontechnical Academic Programms (NTA)
	imparts skills that, in view of the TUHH's training profile, professional engineering studi require but are not able to cover fully. Self-reliance, self-management, collaboration are professional and personnel management competences. The department implements the training objectives in its <b>teaching architecture</b> , in its <b>teaching and learning arrangements</b> , <b>teaching areas</b> and by means of teaching offerings in which students can qualify by opting f <b>specific competences</b> and a <b>competence level</b> at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementa courses.
	The Learning Architecture
	consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling TUHH degree courses.
	The learning architecture demands and trains independent educational planning as regar the individual development of competences. It also provides orientation knowledge in the fo of "profiles".
	The subjects that can be studied in parallel throughout the student's entire study program need be, it can be studied in one to two semesters. In view of the adaptation problems the individuals commonly face in their first semesters after making the transition from school university and in order to encourage individually planned semesters abroad, there is obligation to study these subjects in one or two specific semesters during the course studies.
	Teaching and Learning Arrangements
	provide for students, separated into B.Sc. and M.Sc., to learn with and from each other acro semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learnin in courses are part of the learning architecture and are deliberately encouraged in speci courses.
Knowledge	Fields of Teaching
<i>Kilowieuge</i>	are based on research findings from the academic disciplines cultural studies, social studie arts, historical studies, communication studies, migration studies and sustainability researce and from engineering didactics. In addition, from the winter semester 2014/15 students on Bachelor's courses will have the opportunity to learn about business management and sta 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-oriented communication skills, e.g. the skills required outgoing engineers in international and intercultural situations.
	The Competence Level

#### [7]

	of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.					
	This is also reflected in the different quality of soft skills, which relate to the different teapositions and different group leadership functions of Bachelor's and Master's graduates their future working life.					
	Specialized Competence (Knowledge)					
	Students can					
	<ul> <li>explain specialized areas in context of the relevant non-technical disciplines,</li> <li>outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,</li> <li>different specialist disciplines relate to their own discipline and differentiate it as well as make connections,</li> <li>sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,</li> <li>Can communicate in a foreign language in a manner appropriate to the subject.</li> </ul>					
	Professional Competence (Skills)					
	In selected sub-areas students can					
Skills	<ul> <li>apply basic and specific methods of the said scientific disciplines,</li> <li>aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,</li> <li>to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner,</li> <li>justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.</li> </ul>					
Personal Competence						
	Students will be able					
Social Competence	<ul> <li>to learn to collaborate in different manner,</li> <li>to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,</li> <li>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).</li> </ul>					
	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					
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Autonomy	<ul> <li>application</li> <li>to organize themselves and their own learning processes</li> <li>to reflect and decide questions in front of a broad education background</li> <li>to communicate a nontechnical item in a competent way in writen form or verbaly</li> <li>to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)</li> </ul>
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.

#### TUHH Hamburg University of Technology

Module M1173: A	pplied Statistics					
Courses						
Title		Тур	Hrs/wk	СР		
Applied Statistics (L1584)		Lecture	2	3		
Applied Statistics (L1586)		Project-/problem-based Learning	2	2		
Applied Statistics (L1585)		Recitation Section (small)	1	1		
Module Responsible	Prof. Michael Morlock					
Admission Requirements	None					
Recommended Previous Knowledge	Basic knowledge of statistical m	ethods				
Educational Objectives	After taking part successfully, stu	idents have reached the following lea	rning resu	lts		
Professional Competence						
Knowledge	Students can explain the statistical methods and the conditions of their use.					
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results					
Personal Competence						
Social Competence	Team Work, joined presentation of results					
Autonomy	To understand and interpret the question and solve					
Workload in Hours	Independent Study Time 110, St	udy Time in Lecture 70				
Credit points	6					
Course achievement	Compulsory BonusFormYesNoneWritte	Description	on			
Examination						
Examination duration and scale	90 minutes, 28 questions					
-	Mechatronics: Specialisation Sy Mechatronics: Specialisation Int Biomedical Engineering: Core q Product Development, Materials Theoretical Mechanical Enginee	anagement: Specialisation Manageme stem Design: Elective Compulsory elligent Systems and Robotics: Electiv ualification: Compulsory and Production: Core qualification: E ering: Technical Complementary Cour ering: Specialisation Bio- and Medic	ve Compul lective Con se: Elective	sory mpulsory e Compulsory		

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

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

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

Courses						
<b>Fitle</b> Medical Imaging Systems	(L0819)		<b>Typ</b> Lecture	Hrs/wk 4	<b>CP</b> 6	
Module Responsible		ISS				
Admission Requirements	None					
Recommended Previous Knowledge	none					
Educational Objectives	After taking par	t successfully, studer	nts have reached the follow	ving learning resu	lts	
Professional Competence						
Knowledge	<ul> <li>Students can:</li> <li>Describe the system configuration and components of the main clinical imaging systems;</li> <li>Explain how the system components and the overall system of the imaging systems function;</li> <li>Explain and apply the physical processes that make imaging possible and use with the fundamental physical equations;</li> <li>Name and describe the physical effects required to generate image contrasts;</li> <li>Explain how spatial and temporal resolution can be influenced and how to characterize the images generated;</li> <li>Explain which image reconstruction methods are used to generate images;</li> </ul> Describe and explain the main clinical uses of the different systems.					
Skills	mathem o o o	atical or physical eq Calculate the parar physical equations; Determine the influe emporal resolution o	neters of imaging system	ms using the ma	thematical e spatial ar	
	Select a suitabl	e imaging system for	r an application.			
Personal Competence						
Social Competence	1					
,	Students can:					
Autonomy	<ul> <li>Understand which physical effects are used in medical imaging;</li> <li>Decide independently for which clinical issue a measuring system can be used.</li> </ul>					
Workload in Hours	Independent Si	udy Time 124, Study	Time in Lecture 56			
Credit points	6					
Course achievement	None					
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and scale	
Assignment for the Following Curricula	COMPLUSORV

Course L0819: Medica	I Imaging Systems
Тур	Lecture
Hrs/wk	4
СР	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	<ul> <li>Primary book:</li> <li>1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press</li> <li>Secondary books:</li> <li>A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003.</li> <li>W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002.</li> <li>H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995.</li> <li>O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.</li> </ul>

### Module M1179: Medical Basics and Pathology

Courses				
Title		Тур	Hrs/wk	СР
Medical Basics and Patho	logy I (L1599)	Lecture	2	2
Medical Basics and Patho	logy II (L1600)	Lecture	2	2
Medical Basics and Patho	logy III (L1602)	Lecture	2	2
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stuc	lents have reached the followi	ng learning resu	lts
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Stud	y Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 minutes			
Assignment for the Following Curricula	Biomedical Engineering: Core qu	alification: Compulsory		

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

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

Course L1602: Medica	I Basics and Pathology III
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Dominic Wichmann
Language	DE
Cycle	WiSe
Content	<ul> <li>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</li> <li>b) Basic understanding of the pathology/pathophysiology of pulmonary diseases and their stage-adapted treatments: asthma, chronic obstructive pulmonary disease, pneumonia, bronchial cancer</li> </ul>
	c) Basic understanding of infectious diseases, immune-system and autoimmune diseases
Literature	Skript zur Vorlesung.

ourses				
<b>itle</b> Practical Course Product	Development, Materials and Production (L1566)	<b>Typ</b> Practical Course	Hrs/wk 6	<b>CP</b> 6
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge		als, Metallic Materia s of Polymers, Str ers and Composites ology, Methods of pro	ls for Aircraft ructure and	Properties
Educational Objectives	After taking part successfully, students have r	eached the following	learning resu	lts
Professional Competence	Students can			
Knowledge	<ul> <li>represent more complex context of dif</li> <li>describe functionality of modern technologies.</li> </ul>		umentations	and machir
	<ul> <li>Students are capable of</li> <li>applying theoretical knowledge for provided experimental mether at a study.</li> </ul>		contexts of diff	erent fields
Skills	<ul> <li>study.</li> <li>analyzing and evaluating experiment.</li> <li>applying modern measurement instru</li> </ul>		ovided methoc	ls.
Personal Competence	Students can			
Social Competence	<ul> <li>carry out and document experimental</li> <li>present and discuss experimental res</li> </ul>		f different field	s of study.

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Autonomy	<ul> <li>Students are able to</li> <li>carry out parts of experimental work independently guided by teachers.</li> <li>choose and apply suitable instruments.</li> <li>assess own strengths and weaknesses.</li> </ul>
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	
_	Biomedical Engineering: Core qualification: Compulsory Product Development, Materials and Production: Core qualification: Compulsory

Course L1566: Practic	al Course Product Development, Materials and Production
Тур	Practical Course
Hrs/wk	6
СР	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	<ul> <li>Product Development:</li> <li>Modal analysis - experimental and computational</li> <li>Appropriate design in engineering</li> <li>Characterization of rubbery-elastic materials</li> <li>Stick-Slip-Analysis at friction and wear test station</li> </ul> Materials: <ul> <li>Property profiles of steel</li> <li>Actuators for modern fuel injection systems - synthesis and properties</li> <li>Processing, properties and structure of thermoplastic polymers and its composites</li> <li>Tribology in joints</li> </ul> Production: <ul> <li>Optimization of welding process parameters for hybrid plasma laser welding</li> <li>Evaluation of stock removal processes</li> <li>Analysis of basic laws in production logistics</li> <li>Analysis of positioning behaviour and trajectory accuracy of industrial robots</li> </ul>
Literature	Nach Themenstellung / depending on topic

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Courses				
Title Casestudies Surgery and	Internal Medicine (1 1603)	<b>Typ</b> Seminar	Hrs/wk 5	<b>CP</b> 5
Casestudies Surgery and Internal Medicine (L1603) Clinical Internship (L1587)		Practical Course	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	The lectures addressing medica respective BSc Programs.	l issues from the concentration Bi	omedical Eng	ineering in th
Educational Objectives	After taking part successfully, stu	dents have reached the following	learning resu	lts
Professional Competence				
Knowledge	The students learn the process of clinical practice regarding medical history, diagnosis an treatment decision with representative surgical and medical diseases in the variou departments, and get an insight into the daily patient care through case studies in a hospital.			
	Interpreting and explaining the n	nedical history and medical record	ds of a patient.	
Skills	Dealing with patients.			
Personal				
Competence				
Social Competence	Dealing with patients.			
Autonomy				
Workload in Hours	Independent Study Time 96, Stu	dy Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	5 Pages (10 Case studies)			
Assignment for the				

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
Content	<ul> <li>demonstriert. Alle 1-2 Tage wechseln die Stationen hierzu gehören:</li> <li>Notaufnahme</li> <li>Intensivstation</li> <li>Pneumologie</li> <li>Gastroenterologie</li> <li>Kardiologie</li> <li>Transfusionsmedizin</li> <li>Poliklinik/Ambulanz</li> <li>Dialyse</li> </ul>
Literature	- Unfallchirugie keine spezifische

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

Module M1214: S	Study work		
Courses			
Title	Typ Hrs/wk CP		
-	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Subjects of the Master program and the specialisations.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	<ul> <li>Students can explain the project as well as their autonomously gained knowledge and relate it to current issues of their field of study.</li> <li>They can explain the basic scientific methods they have worked with.</li> </ul>		
Skills	The students are able to autonomously solve a limited scientific task under the guidance of a experienced researcher. They can justify and explain their approach for problem solving; the can draw conclusions from their results, and then can find new ways and methods for the work. Students are capable of comparing and assessing alternative approaches with the 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 for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their peers and supervisors.		
Autonomy	The students are capable of independently planning and documenting the work steps an procedures while considering the given deadlines. This includes the ability to accurate procure the newest scientific information. Furthermore, they can obtain feedback from experimitely with regard to the progress of the work, and to accomplish results on the state of the art is science and technology.		
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0		
Credit points	12		
Course achievement	None		
Examination	Study work		
Examination duration and scale	Laccording to ESP()		
Assignment for the Following Curricula	I BIOMAGICAL ENGINAARING' L'ORA GUAUTICATION' L'OMPULICON/		

## **Specialization Implants and Endoprostheses**

Madula M0622. k	atalligant Svatama i	in Madiaina			
	ntelligent Systems i				
Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Mec			Lecture	2	3
Intelligent Systems in Mec			Project Seminar	2	2
Intelligent Systems in Mec	dicine (L0333)		Recitation Section (small)	) 1	1
	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>principles of stoch</li> </ul>	amming, Java/C++ a			
Educational Objectives	Attor taking nart europeeti	ully, students have re	eached the following lea	arning resu	lts
Professional					
Competence					
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
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.			classification, tient data and	
Personal Competence					
Social Competence	The students discuss the results of other groups, provide helpful feedback and car incoorporate feedback into their work.				
Autonomy		The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			ork. They can
Workload in Hours	Independent Study Time 1	110, Study Time in L	ecture 70		
Credit points	6				
Course achievement	Compulsory BonusYes10 %Yes10 %	Form Written elaboration Presentation	Descriptio	on	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Specia Electrical Engineering: Sp Computational Science a Elective Compulsory	ecialisation Medical	Technology: Elective C	Compulsory	/

	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0331: Intellige	ent Systems in Medicine
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>
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: Intellige	ent Systems in Medicine
Тур	Project Seminar
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

#### TUHH Hamburg University of Technology

### Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Title		Тур	Hrs/wk	СР
	ents and Cognitive Robotics (L0341) ents and Cognitive Robotics (L0512)	Lecture	2	4 2
		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students h	nave reached the following lea	rning resu	lts
Professional Competence				
Knowledge	Students can explain the agent abstra and give details about agent design ( main features of environments. The not in terms of decision problems and alg uncertainty in real-world scenarios, stu employed as a knowledge represent settings. In addition, students can de sequential settings, with and with con context, students can describe technique problems, and they can recall technique identify techniques for simultaneous if techniques for achieving desired state decision making in a multi-agent setting functions, voting protocol, and mechani	goals, utilities, environments) tion of adversarial agent coope gorithms for solving these pro- idents can summarize how Ba ation and reasoning formalisr define decision making pro- nplete access to the state of ues for solving (partially obse es for measuring the value of in localization and mapping, an es. Students can explain coo ng in term of different types of sm design techniques.	. They car eration can blems. Fo yesian ne n in static cedures ir the enviro rvable) Ma nformation d can exp ordination equilibria,	a describe t be discuss r dealing w tworks can and dynan a simple a nment. In the arkov decisi . Students c blain planni problems a social choi
Skills	Students can select an appropriate scenarios. For simplified agent applicat optimization techniques. For those networks/dynamic Bayesian networks Students can also name and apply scenarios. For simple and complex dee policies for concrete settings. In mult finding different equilibria states,e.g. students will apply different voting proto	tion students can derive decisi e applications they can and apply bayesian reasor different sampling techniqu cision making students can co ti-agent situations students w , Nash equilibria. For multi-	on trees an also creat ing for si es for sin mpute the ill apply t agent dec	nd apply bas ate Bayesi mple querie nplified age best action echniques sision maki
Personal Competence				
Social Competence	Students are able to discuss their sol English	utions to problems with other	s. They co	mmunicate
Autonomy	Students are able of checking their und concrete problems	derstanding of complex conce	ots by solv	ing varaints
Workload in Hours	Independent Study Time 124, Study Tin	ne in Lecture 56		
Credit points	6			
	Nama			
Course achievement	None			

[26]

and scale	
-	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: 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 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Tur	Lecture
тур Hrs/wk	
_	
	Independent Study Time 92, Study Time in Lecture 28 Rainer Marrone
Language	
Content	<ul> <li>Definition of agents, rational behavior, goals, utilities, environment types</li> <li>Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minima algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty: Motivation: agents with no direct access to the state(s) of the environmer probabilities, conditional probabilities, product rule, Bayes rule, full joint probabili distribution, marginalization, summing out, answering queries, complexit independence assumptions, naive Bayes, conditional independence assumptions</li> <li>Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference the enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynam Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special case hidden Markov models, Kalman filters, Exact inferences and approximations</li> </ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvie Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17</li> <li>Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005</li> <li>Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoa Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009</li> </ol>

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

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

Courses			
Title	Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Most important types of waveguides and their properties</li> <li>Radiation and basic antenna parameters</li> <li>Most important types of antennas and their properties</li> <li>Numerical techniques and CAD tools for waveguide and antenna design</li> <li>Fundamentals of Electromagnetic Compatibility</li> <li>Coupling mechanisms and countermeasures</li> <li>Shielding, grounding, filtering</li> <li>Standards and regulations</li> <li>EMC measurement techniques</li> </ul>
Literature	<ul> <li>Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

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

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

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

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

Course L1890: Seminar Biomedical Engineering	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and 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
СР	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	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>
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 M	lechanics II		
Тур	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration			
and scale			
Lecturer	Prof. Michael Schlüter		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>		
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>		

Course L1820: System	n Simulation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	'30 min	
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>	
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>	

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

Course L0379: Ceramics Technology		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62	, Study Time in Lecture 28
Examination Form		
Examination duration and scale	90 Minuten	
Lecturer	Dr. Rolf Janßen	
Language	DE/EN	
Cycle	WiSe	
	course focus predominat techniques and sintering ( cement science as well as and ceramic composites w	becessing with emphasis on advanced structural ceramics. The ly on powder-based processing, e.g. "powder-metauurgical soild state and liquid phase). Also, some aspects of glass and new developments in powderless forming techniques of ceramics rill be addressed Examples will be discussed in order to give derstanding of technology development and specific applications
	Content:	1. Introduction
	Inhalt:	2. Raw materials
Content		3. Powder fabrication
		4. Powder processing
		5. Shape-forming processes
		6. Densification, sintering
		7. Glass and Cement technology
		8. Ceramic-metal joining techniques
	W.D. Kingery, "Introduction t	o Ceramics", John Wiley & Sons, New York, 1975
	ASM Engineering Materials	Handbook Vol.4 "Ceramics and Glasses", 1991
Literature	D.W. Richerson, "Modern C	eramic 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	СР	
Nature's Hierarchical Materials (L1663)	Seminar	2	3	
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4	
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2	
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3	
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3	
Numerical Methods in Biomechanics (L1583)	Seminar	2	3	
Seminar Biomedical Engineering (L1890)	Seminar	2	3	
Six Sigma (L1130)	Lecture	2	3	
Fluid Mechanics II (L0001)	Lecture	2	4	
System Simulation (L1820)	Lecture	2	2	
System Simulation (L1821)	Recitation Section (large)	1	2	
Ceramics Technology (L0379)	Lecture	2	3	

-	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 Curricula	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

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

Course L1669: Introdu	ction to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Most important types of waveguides and their properties</li> <li>Radiation and basic antenna parameters</li> <li>Most important types of antennas and their properties</li> <li>Numerical techniques and CAD tools for waveguide and antenna design</li> <li>Fundamentals of Electromagnetic Compatibility</li> <li>Coupling mechanisms and countermeasures</li> <li>Shielding, grounding, filtering</li> <li>Standards and regulations</li> <li>EMC measurement techniques</li> </ul>
Literature	<ul> <li>Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

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

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

Course L1580: Experimental Methods for the Characterization of Materials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>	
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: Numer	ical Methods in Biomechanics
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Vorkenntnisse aus "Diskretisierungsmethoden der Mechanik" sind empfohlen</li> <li>Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt.</li> <li>Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten</li> <li>Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden</li> <li>Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt.</li> <li>Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.</li> </ul>
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L1130: Six Sig	ma
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Claus Emmelmann
Language	DE
Cycle	WiSe
Content	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>
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 M	lechanics II					
Тур	Lecture					
Hrs/wk	2					
СР	4					
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28					
Examination Form	(lausur					
Examination duration						
and scale						
Lecturer	Prof. Michael Schlüter					
Language	DE					
Cycle	WiSe					
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>					
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>					

Course L1820: System	n Simulation				
Тур	Lecture				
Hrs/wk	2				
СР	2				
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28				
Examination Form	Jündliche Prüfung				
Examination duration and scale	30 min				
Lecturer	Dr. Stefan Wischhusen				
Language	DE				
Cycle	WiSe				
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>				
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>				

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

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

Courses						
<b>Title</b> Microsystem Engineering	ı (L0680)		<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 4	
Microsystem Engineering	I (L0682)		Project-/problem-based Learning	2	2	
Module Responsible	Prof. Manfred Kasper					
Admission Requirements	Nono					
Recommended Previous Knowledge	Racio courcos in nhvi	sics, mathematics a	and electric engineering			
Educational Objectives	Atter taking part succ	essfully, students h	ave reached the following le	arning resu	lts	
Professional Competence						
Knowledge	The students know a their applications in s		ortant technologies and mate ors.	erials of ME	MS as well	
Skills	Students are able to a to evaluate the poten		be the functional behaviour o s.	of MEMS co	mponents a	
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.					
		owiedge with other		i illerature a	nd to integra	
	Independent Study T		fields.	niterature a	nd to integra	
	Independent Study T		fields.		nd to integra	
Workload in Hours Credit points	Independent Study T 6 Compulsory Bonus		fields. ne in Lecture 56 Descript		nd to integra	
Workload in Hours Credit points Course achievement	Independent Study T 6 Compulsory Bonus	me 124, Study Tim	fields. ne in Lecture 56 Descript		nd to integra	
Workload in Hours Credit points Course achievement	Independent Study T 6 Compulsory Bonus No 10 % Written exam	me 124, Study Tim <b>Form</b> Presentation	fields.		nd to integra	



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0680: Micros	ystem Engineering				
Тур	Lecture				
Hrs/wk	2				
СР	4				
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28				
Lecturer	Prof. Manfred Kasper				
Language					
Cycle					
	Object and goal of MEMS Scaling Rules Lithography Film deposition Structuring and etching Energy conversion and force generation				
Content	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: Micros	Course L0682: Microsystem Engineering			
Тур	Project-/problem-based Learning			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	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			

Module M0751: V	ibration Theory				
Courses					
<b>Title</b> Vibration Theory (L0701)	TypHrs/wkCPIntegrated Lecture46				
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	• Linear Algebra				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them furthe				
Skills	Students are able to denote methods of Vibration Theory and develop them further.				
Personal Competence					
-	I Students can reach working results also in groups.				
	Students are able to approach individually research tasks in Vibration Theory.				
	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	12 Hours				
-	<ul> <li>Energy Systems: Core qualification: Elective Compulsory</li> <li>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory</li> <li>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compuls</li> <li>Mechatronics: Core qualification: Compulsory</li> <li>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</li> <li>Product Development, Materials and Production: Core qualification: Compulsory</li> <li>Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory</li> <li>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory</li> </ul>				

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

	licrosystems Technolog	gy in Theory and	Practice			
Courses						
<b>Title</b> Microsystems Technolog	y (L0724)	<b>Typ</b> Lecture		<b>Hrs/wk</b> 2	<b>CP</b> 4	
Microsystems Technology (L0725) Pr			oroblem-based	2	2	
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	Nono					
Recommended Previous Knowledge	Basics in physics, chemistry, me	chanics and semicond	uctor technolo	ду		
Educational Objectives	After taking part successfully, stu	udents have reached th	e following lea	arning resu	lts	
Professional Competence						
Competence	Students are able					
Kanadan	<ul> <li>to present and to explain cu methods for the fabrication of thereof in more complex system;</li> </ul>	microsensors and mic				
Knowledge	• to explain in details operation principles of microsensors and microactuators and					
	• to discuss the potential and limitation of microsystems in application.					
	Students are capable					
	• to analyze the feasibility of microsystems,					
	to develop process flows for the fabrication of microstructures and					
Skills	• 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 front of audience.					
Autonomy	None					
Workload in Hours	Independent Study Time 124, St	tudy Time in Lecture 56	3			
Credit points	6					
	Compulsory Bonus Form	1	<b>Descriptio</b> Studierend Kleingrupp	den fi	ühren i aborpraktikur	
	I					



Course achievement	Yes None	Subject theoretical practical work	and durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebniise ihrer Labortätigkeit. vor dem gesamten Kurs.	
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula	Elective Compulsory Electrical Engineering: Computational Science Elective Compulsory International Manager Compulsory Biomedical Engineering Biomedical Engineering Biomedical Engineering Compulsory Biomedical Engineering Compulsory	Specialisation Medical Techn and Engineering: Specialis ment and Engineering: S g: Specialisation Artificial Org g: Specialisation Implants and g: Specialisation Medical T	ation Systems Engineering and Robotics: pecialisation II. Mechatronics: Elective gans and Regenerative Medicine: Elective d Endoprostheses: Elective Compulsory echnology and Control Theory: Elective ent and Business Administration: Elective	

Course L0724: Micros	ystems Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul> <li>Introduction (historical view, scientific and economic relevance, scaling laws)</li> <li>Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive; angular rate sensor: operating principle and fabrication process)</li> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR,</li> </ul>

	<ul> <li>fluxgate magnetometer)</li> <li>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)</li> <li>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)</li> <li>MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration)</li> <li>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)</li> <li>System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>
	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
Literature	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

0291)	Тур	Hrs/wk	
,			СР
0804)	Lecture Recitation Se	2 ection (large) 2	3 3
Prof. Otto von Estorff			0
Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics Dynamics) Mathematics I, II, III (in particular differential equations)			
After taking part successfully	, students have reached the fo	llowing learning resul	lts
method and are able to g			
-	, , , ,		<u> </u>
Students can work in small (	roups on specific problems to	arrive at joint solution	S.
develop own finite element			
Independent Study Time 12	4, Study Time in Lecture 56		
6			
		Description	
Written exam			
120 min			
	Dynamics)         Mathematics I, II, III (in partic         After taking part successfully         The students possess an in         method and are able to gi         method.         The students are capable         elements, assembling the core         equations.         Students can work in small g         The students are able to         develop own finite element         scrutinized.         Independent Study Time 124         6         Compulsory Bonus       F         No       20 %         Written exam         120 min	Mechanics I (Statics, Mechanics of Materials) and Mech         Dynamics)         Mathematics I, II, III (in particular differential equations)         After taking part successfully, students have reached the form         The students possess an in-depth knowledge regarding method and are able to give an overview of the theorem         The students are capable to handle engineering probelelements, assembling the corresponding system matrices, equations.         Students can work in small groups on specific problems to The students are able to independently solve challen develop own finite element routines. Problems can be ide scrutinized.         Independent Study Time 124, Study Time in Lecture 56         6         Compulsory Bonus       Form         No       20 %       Midterm         Written exam       Studerm	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics Dynamics)         Mathematics I, II, III (in particular differential equations)         After taking part successfully, students have reached the following learning result         The students possess an in-depth knowledge regarding the derivation of the method and are able to give an overview of the theoretical and methodica method.         The students are capable to handle engineering problems by formulating elements, assembling the corresponding system matrices, and solving the result equations.         Students can work in small groups on specific problems to arrive at joint solution The students are able to independently solve challenging computational provelop own finite element routines. Problems can be identified and the result scrutinized.         Independent Study Time 124, Study Time in Lecture 56         6         Compulsory Bonus       Form       Description         No       20 %       Midterm         Written exam       120 min         Civil Engineering: Core qualification: Compulsory       Compulsory Bonus Form       Description

	International Management and Engineering: Specialisation II. Mechatronics: Elective
	Compulsory International Management and Engineering: Specialisation II. Product Development and
	Production: Elective Compulsory
Assignment for the	Mechatronics: Core qualification: Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
	Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
	Compulsory
	Product Development, Materials and Production: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Compulsory

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

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

courses				
ītle		Тур	Hrs/wk	СР
echnology Management	(L0849)	Project-/problem-based Learning	3	3
echnology Management	Seminar (L0850)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business ma	anagement		
Educational Objectives	After taking part successfully, studer	nts have reached the following lea	arning resu	lts
Professional				
Competence	Students will gain deep insights into			
Knowledge	<ul> <li>Technology Timing Strategie</li> <li>Technology Strategie</li> <li>Technology Intelliger</li> <li>Technology Portfolio Manag</li> <li>Technology Portfolio</li> <li>Technology Acquisiti</li> <li>IP Management</li> <li>Organizing Technology Devo</li> <li>Technology Organiza</li> <li>Technology Funding</li> </ul>	es and Lifecycle Management (I/II) nce and Planning ement Methodology on and Exploitation elopment ation & Management	)	
Skills	<ul> <li>The course aims to:</li> <li>Develop an understanding of the importance of Technology Management - on national as well as international level</li> <li>Equip students with an understanding of important elements of Technolo Management (strategic, operational, organizational and process-related aspects)</li> <li>Foster a strategic orientation to problem-solving within the innovation process as w as Technology Management and its importance for corporate strategy</li> <li>Clarify activities of Technology Management (e.g. technology sourcing, maintenan and exploitation)</li> <li>Strengthen essential communication skills and a basic understanding of manageri organizational and financial issues concerning Technology-, Innovation- and R&amp; management. Further topics to be discussed include:</li> <li>Basic concepts, models and tools, relevant to the management of technology, R&amp; and innovation</li> </ul>		f Technolog aspects) rocess as we , maintenanc of manageria on- and R&D	
Personal Competence	<ul> <li>Innovation as a process (step)</li> </ul>	ps, activities and results)		
Social Competence	<ul><li>Interact within a team</li><li>Raise awareness for globab</li></ul>	Lingung		

Autonomy	<ul> <li>Discuss recent research debates in the context of Technology and Innovation Management</li> <li>Develop presentation skills</li> <li>Discussion of international cases in R&amp;D-Management</li> </ul>		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

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

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

Courses					
<b>Fitle</b> Control Systems Theory a Control Systems Theory a			<b>Typ</b> Lecture Recitation Section (	Hrs/wk 2 small) 2	<b>CP</b> 4 2
Module Responsible		er			
Admission Requirements					
Recommended Previous Knowledge	Introduction to Con	trol Systems			
Educational Objectives	After taking part suc	ccessfully, students h	ave reached the followir	ng learning resu	Its
Professional Competence					
Knowledge	<ul> <li>Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space</li> <li>They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively</li> <li>They can explain the significance of a minimal realisation</li> <li>They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain state space models and transfer function models of discrete-time systems</li> <li>They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation</li> <li>They can explain how a state space model can be constructed from a discrete-time impulse response</li> </ul>				
Skills	<ul> <li>Students can transform transfer function models into state space models and versa</li> <li>They can assess controllability and observability and construct minimal realisations</li> <li>They can design LQG controllers for multivariable plants</li> <li>They can carry out a controller design both in continuous-time and discrete-tidomain, and decide which is appropriate for a given sampling rate</li> <li>They can identify transfer function models and state space models of dynamic syster from experimental data</li> <li>They can carry out all these tasks using standard software tools (Matlab Con Toolbox, System Identification Toolbox, Simulink)</li> </ul>				
Personal Competence					
Social Competence	Students can work	in small groups on sp	pecific problems to arrive	at joint solution	IS.
	Students can obtain information from provided sources (lecture notes, softwar documentation, experiment guides) and use it when solving given problems.				
Autonomy	They can assess t progress.	heir knowledge in w	eekly on-line tests and	thereby control	their learnin

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	

Course L0656: Contro	I Systems Theory and Design			
Тур	Lecture			
Hrs/wk	2			
СР	4			
Workload in Hours	ndependent 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 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         • Balanced realization and model order reduction         Case study         • Modelling and multivariable control of			
Literature	<ul> <li>Werner, H., Lecture Notes "Control Systems Theory and Design"</li> <li>T. Kailath "Linear Systems", Prentice Hall, 1980</li> <li>K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997</li> <li>L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999</li> </ul>			

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

Module M0867: F	Production Planning & Con	trol and Digital Ente	erprise			
	<b>3</b>	<b>..</b>	•			
Courses						
Title		Тур	Hrs/wk	СР		
The Digital Enterprise (L0	932)	Lecture	2	2		
Production Planning and (	-	Lecture	2	2		
Production Planning and (	Control (L0930)	Recitation Section	(small) 1	1		
Exercise: The Digital Ente	erprise (L0933)	Recitation Section	(small) 1	1		
Module Responsible	Prof. Hermann Lödding					
Admission Requirements	None					
Recommended Previous Knowledge	Fundamentals of Production and Qu	ality Management				
Educational Objectives	After taking part successfully, studen	ts have reached the followi	ng learning resul	lts		
Professional						
Competence						
Knowledge	Students can explain the contents of	the module in detail and ta	ike a critical posit	tion to them.		
Skills	Students are capable of choosing industrial problems.	and applying models and	l methods from t	the module to		
Personal						
Competence						
Social Competence	Students can develop joint solutions	in mixed teams and preser	nt them to others.			
Autonomy	-					
Workload in Hours	Independent Study Time 96, Study T	ime in Lecture 84				
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and scale	180 Minuten					
	International Management and En	gineering: Specialisation	II. Product Deve	elopment and		
	Production: Elective Compulsory	litu Oppoialiaatian Durd	otion and latin	otion. Electrica		
	Logistics, Infrastructure and Mobi Compulsory	my. Specialisation Produ	cuon and Logis			
	Biomedical Engineering: Specialisat	ion Artificial Organs and R	egenerative Med	licine: Elective		
	Compulsory	5	0			
	Biomedical Engineering: Specialisat					
	Biomedical Engineering: Specialisa	tion Medical Technology	and Control Th	eory: Elective		
Assignment for the	Compulsory Biomedical Engineering: Special	isation Management ar	nd Business A	Administration		
Following Curricula	Compulsory	isation management a				
	Product Development, Materials	and Production: Specialis	sation Product	Development:		
	Elective Compulsory	Des du stieres O se si all'a di	Duraduation			
	Product Development, Materials and Product Development Materials					
	Product Development, Materials and Production: Specialisation Materials: Elective Compulsory					
	Theoretical Mechanical Engineering: Specialisation Product Development and Production:					
	Elective Compulsory					
	Theoretical Mechanical Engineering	: Technical Complementar	y Course: Elective	e Compulsory		

ourse L0932: The Dig				
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 virtua 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: Produc	Course L0929: Production Planning and Control			
Тур	Lecture			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Hermann Lödding			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Models of Production and Inventory Management</li> <li>Production Programme Planning and Lot Sizing</li> <li>Order and Capacity Scheduling</li> <li>Selected Strategies of PPC</li> <li>Manufacturing Control</li> <li>Production Controlling</li> <li>Supply Chain Management</li> </ul>			
Literature	<ul> <li>Vorlesungsskript</li> <li>Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008</li> <li>Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002</li> </ul>			

Course L0930: Production Planning and Control		
Тур	Recitation Section (small)	
Hrs/wk	1	
СР	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: Exercis	ourse L0933: Exercise: The Digital Enterprise				
Тур	Recitation Section (small)				
Hrs/wk	1				
СР	1				
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14				
Lecturer	Dr. Axel Friedewald				
Language	DE				
Cycle					
Content	See interlocking course				
Literature	Siehe korrespondierende Vorlesung See interlocking course				

Module M0921: E	Electro	onic Cire	cuits for	Medical App	olications			
Courses								
<b>Title</b> Electronic Circuits for Medical Applications (L0696) Electronic Circuits for Medical Applications (L1056)					<b>Typ</b> Lecture Recitation Section (	(small)	<b>Hrs/wk</b> 2 1	<b>CP</b> 3 2
Electronic Circuits for Me	dical App	olications (L1	408)		Practical Course		1	1
Module Responsible		latthias Kul	nl					
Admission Requirements	None							
Recommended Previous Knowledge	I FIINGO	mentals of	electrical en	gineering				
Educational Objectives	Atter ta	aking part s	uccessfully,	students have re	ached the following	ng lea	rning resu	lts
Professional Competence								
Knowledge	•	nervous s Students along an a Students Students applicatio Students	ystem are able to axon can exemplif can descril ns can explain t are able to	explain the build fy the communica be the special the functions of p	onality of the info d-up of an action ation between neu features of low- rostheses, e. g. ar rential and limitat	poter irons a noise n artifi	ntial and it and electro amplifiers cial hand	s propagation onic devices s for medical
Skills	•	Students signal acc Students	can give so juisition. can develop	the block diagra	ndent voltage beh her improvement ams of prosthetic s s of electronic sys	of lo system	w-noise a Is	nd low-power
Personal Competence								
Social Competence	•	together w Students assistance Students o	vith experts v are able to to the right can docume	with different prof recognize their time. nt their work in a	ns in the field of ressional backgrou r specific limitatio a clear manner an never it is necessa	und. ons, so d com	o that the	y can ask for
Autonomy	•	actions for Students of work in a r	r improveme can break do realistic way can handle	nts when necess own their work in	ge the status of the sary. a appropriate work a structures of bio	c pack	ages and	schedule their



	<ul> <li>Students are able experimental work</li> </ul>	e to act in a responsible manner in all cases and situations of k.
Workload in Hours	Independent Study Time	124, Study Time in Lecture 56
Credit points	6	
	Compulsory Bonus	Form Description
Course achievement	Yes None	Subject theoretical and practical work
	No None	Excercises
Examination	Written exam	
Examination duration and scale	190 min	
Assignment for the Following Curricula	Biomedical Engineering: Compulsory Biomedical Engineering: Biomedical Engineering: Biomedical Engineering: Compulsory Microelectronics and Mic Compulsory Theoretical Mechanical E Compulsory	pecialisation Medical Technology: Elective Compulsory Specialisation Artificial Organs and Regenerative Medicine: Elective Specialisation Implants and Endoprostheses: Elective Compulsory Specialisation Medical Technology and Control Theory: Compulsory Specialisation Management and Business Administration: Elective crosystems: Specialisation Microelectronics Complements: Elective Engineering: Specialisation Bio- and Medical Technology: Elective Engineering: Technical Complementary Course: Elective Compulsory

Course L0696: Electro	onic Circuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	
Cycle	WiSe
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>
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
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1408: Electronic Circuits for Medical Applications		
Тур	Practical Course	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Prof. Matthias Kuhl	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>	
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/	



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Courses				
<b>Title</b> Continuum Mechanics (L1	533)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Continuum Mechanics Ex		Recitation Section (small)		3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces an moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strai energy).			
Educational Objectives	After taking part successfully, students have re	eached the following lea	rning result	S
Professional Competence				
Knowledge	The students can explain the fundamental comaterials.	oncepts to calculate the	mechanica	I behavior
Skills	The students can set up balance laws and aspects, both in applied contexts as in researc		nation theo	ry to speci
Personal Competence				
Social Competence	The students are able to develop solutions, to develop ideas further.	present them to special	ists in writte	n form and
Autonomy	The students are able to assess their independently and on their own identify a mechanics and acquire the knowledge require	nd solve problems in		-
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: E Mechanical Engineering and Management: S Mechatronics: Technical Complementary Cou Biomedical Engineering: Specialisation Artific Compulsory Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Med Compulsory Biomedical Engineering: Specialisation Man Compulsory	pecialisation Materials: irse: Elective Compulsor cial Organs and Regene nts and Endoprostheses dical Technology and (	rative Medi s: Elective C Control The	cine: Electiv compulsory eory: Electiv



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535) Material Modeling (L1536)		Lecture Recitation Section	2 (small) 2	3 3
		Recitation Section	(Silidii) Z	5
Module Responsible	-			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continu Mechanics II and Continuum Mechanics strain, free-body principle, linear and non	(forces and momen	ts, stress, linear	
Educational Objectives	After taking part successfully, students hav	ve reached the follow	ing learning resu	Its
Professional Competence				
Knowledge	The students can explain the fundamenta	s of multidimensiona	l consitutive mate	erial laws
Skills	The students can implement their own ma students can apply their knowledge to va corresponding material models.			•
Personal				
Competence				
Social Competence	The students are able to develop soluti ideas further.	ons, to present them	n to specialists a	nd to develop
Autonomy	The students are able to assess th independently and on their own identify a and acquire the knowledge required to thi	nd solve problems in		-
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Computational Science and Engineeri Compulsory Materials Science: Specialisation Modelin Mechanical Engineering and Managemen Biomedical Engineering: Specialisation A Compulsory Biomedical Engineering: Specialisation In Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation I Compulsory Product Development, Materials and Proc Theoretical Mechanical Engineering: Spe	g: Elective Compulsont: Specialisation Mat rtificial Organs and F nplants and Endopro- Medical Technology Management and Bu uction: Core qualifica	ory erials: Elective Co Regenerative Mec stheses: Elective and Control Tr usiness Administr ation: Elective Co	ompulsory licine: Elective Compulsory leory: Elective ation: Elective mpulsory

Course L1535: Materia	al Modeling
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: Materia	al Modeling
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: A	dvanced F	unctional <b>N</b>	<b>Naterials</b>			
Courses						
Title Advanced Functional Mat	erials (L1625)			<b>Typ</b> Seminar	Hrs/wk 2	<b>CP</b> 6
Module Responsible	Prof. Patrick Hu	ber				
Admission Requirements	None					
Recommended Previous Knowledge						
Educational Objectives	After taking par	t successfully, s	students have	e reached the follow	ving learning resu	Its
Professional						
Competence			بالا ماماده	nyonovice start.	nood materials -	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.					
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro to the macroscale. The students will also gain an overview on modern materials sciences which enables them to select optimum materials combinations depending on the technical applications.					
Personal Competence						
Social Competence	The students are able to present solutions to specialists and to develop ideas further.			rther.		
	The students a	re able to				
Autonomy						
Workload in Hours	Independent S	udy Time 152,	Study Time ir	n Lecture 28		
Credit points						
Course achievement	None					
Examination	Presentation					
Examination duration and scale	L30 min					
Assignment for the Following Curricula						

Course L1625: Advand	ced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>
Literature	Wird in der Veranstaltung bekannt gegeben

Courses					
<b>Fitle</b>	try and Molecular Biology (L0386)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3	
Module Responsible	Prof. Hans-Jürgen Kreienkamp				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successfully studer	nts have reached the follow	ing learning resul	ts	
Professional Competence					
Knowledge	<ul> <li>The students can</li> <li>describe basic biomolecules;</li> <li>explain how genetic information is coded in the DNA;</li> <li>explain the connection between DNA and proteins;</li> </ul>				
Skills	<ul> <li>The students can</li> <li>recognize the importance of molecular parameters for the course of a disease;</li> <li>describe selected molecular-diagnostic procedures;</li> <li>explain the relevance of these procedures for some diseases</li> </ul>				
Personal Competence					
Social Competence	The students can participate in discu	ussions in research and me	dicine on a techn	ical level.	
Autonomy	The students can develop understa by themselves.	nding of topics from the co	ourse, using techn	ical literatur	
Workload in Hours	Independent Study Time 62, Study	Fime in Lecture 28			
Credit points	3				
Course achievement	None				
	Written exam				
Examination	Willen exam				
	60 minutes	rman program 7 comost	or): Spacializatio	n Biomodia	

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1333: B	BIO I: Implants and Fracture Healing		
Courses			
<b>Title</b> Implants and Fracture Hea	TypHrs/wkbaling (L0376)Lecture2	<b>СР</b> 3	
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Erecture Healing"	"Implants ar	
Educational Objectives	Atter taking part successfully, students have reached the following learning resu	Its	
Professional Competence			
Knowledge	The students can describe the different ways how bones heal, and the requirements for the existence. The students can name different treatments for the spine and hollow bones under give fracture morphologies.		
Skills	The students can determine the forces acting within the human body under situations under specific assumptions.	er quasi-stat	
Personal Competence			
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the internal forces.	calculation	
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the internal forces.	calculation of	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	190 min		
	General Engineering Science (German program, 7 semester): Specialisatio Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisatio Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisatio Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisatio Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Mec Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Biomedical Engineering: Specialisation Medical Technology and Control Th Compulsory Biomedical Engineering: Specialisation Management and Business Administr Compulsory	on Biomedic n Mechanic on Biomedic licine: Electiv Compulsory eory: Electiv	

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Course L0376: Implant	ts and Fracture Healing	
Тур	Lecture	
Hrs/wk	2	
СР		
	Independent Study Time 62, Study Time in Lecture 28	
	Prof. Michael Morlock	
Language Cycle		
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)	
Content	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	
	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	
Literature	Nigg, B.: Biomechanics of the musculo-skeletal system	
	Schiebler T.H., Schmidt W.: Anatomie	
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat	

Module M1334: E	BIO II: Biomaterials				
Courses					
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23				
	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.				
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials				
Personal Competence					
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.				
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory				

Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	

Lecturer Language	Prof. Michael Morlock EN
Cycle	WiSe
	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
Content	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.
	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.
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	[85]

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer 1996.	

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Title		Тур	Hrs/wk	СР		
Structure and Properties of Polymers (L0389)		Lecture	2	3		
Processing and design w	th polymers (L1892)	Lecture	2	3		
Module Responsible	Dr. Hans Wittich					
Admission Requirements	None					
Recommended Previous Knowledge	Basics: chemistry / physics / mat	erial science				
Educational Objectives	After taking part successfully, stu	idents have reached the follow	ving learning resu	lts		
Professional Competence						
	Students can use the knowledge	e of plastics and define the neo	cessary testing and	d analysis.		
	They can explain the complex re	elationships structure-property	relationship and			
Knowledge		tructure of the polymers, ind	cluding to explain	n neighboring		
	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).					
	Students are capable of					
		on mothodo in a givon cou	toxt to mochani	al proportio		
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.					
Chine	- selecting appropriate solutions for mechanical recycling problems and sizing example					
	stiffness, corrosion resistance.			5 F		
Personal						
Competence						
	Students can					
	- arrive at funded work results in	heterogenius groups and doc	ument them.			
Social Competence	- provide appropriate feedback and handle feedback on their own performance constructively.					
	Students are able to					
	- assess their own strengths and weaknesses.					
Autonomy	- assess their own state of learning in specific terms and to define further work steps on this basis.					
	- assess possible consequences of their professional activity.					
Workload in Hours	Independent Study Time 124, St	udy Time in Lecture 56				
Credit points	6					
Course achievement	None					
	Written exam					
Examination duration and scale	180 min					
	Materials Science: Specialisatio	n Engineering Materials: Elect	ive Compulsory			

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
	Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
A a a i www.a wt faw.tha	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
Assignment for the	
Following Curricula	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 Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L0389: Structure and Properties of Polymers				
Тур	Lecture			
Hrs/wk	2			
СР	3			
	dependent Study Time 62, Study Time in Lecture 28			
	Dr. Hans Wittich			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Structure and properties of polymers</li> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology <ul> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> <li>Applications</li> </ul> </li> </ul>			
Litoroturo				
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag			

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

Module M0632: F	Regenerative Medic	ine			
Courses Title			Turn	Hao hule	<u></u>
Regenerative Medicine (L	0347)		<b>Typ</b> Seminar	Hrs/wk 2	<b>СР</b> 3
Lecture Tissue Engineerir	ng - Regenerative Medicine (I	_1664)	Seminar	2	3
Module Responsible	Prof. Ralf Pörtner				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successf	ully, students have	reached the follow	ving learning resu	lts
Professional Competence					
Knowledge	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.				
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic udnerlying principles of the discussed topics. After successful completion of the module students are				
Skills	<ul> <li>able to use medical databases for acquirierung and presentation of relevant up-to-date data independently</li> <li>able to present their work results in the form of presentations</li> <li>able to carry out basic cell culture methods and the corresponding analysis independently</li> <li>able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine.</li> </ul>				
Personal Competence		rk togothor og a t	nom with 2.4 otus	dente te celve di	von tooko on
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 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 independently including a presentation of the results.				
Workload in Hours	Independent Study Time	124, Study Time in	Lecture 56		
Credit points					
Course achievement	Compulsory BonusYes20 %	Form Written elaboratio	Aus	scription arbeitung zu Rir tocol for lecture se	
Examination	Presentation				
Examination duration and scale	()rai presentation + discu	ssion (30 min)			
	I				

Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective	•
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	

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

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

Courses				
-	ciples and Applications (L0371) ciples and Applications (L0373)	<b>Typ</b> Lecture Recitation Section (sr	Hrs/wk 3 nall) 2	<b>CP</b> 5 1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Basic principles of physics			
Educational Objectives	After taking part successfully, st	udents have reached the following	learning resu	lts
Professional Competence				
Knowledge	i.e. the quantification and appli define and exemplify the most i to wavelength and frequency of numerical techniques for chara	principles, relationships, and metl cation of electromagnetic fields ir mportant physical phenomena an f the fields. They can give an over acterization of electromagnetic fiel erapeutic and diagnostic utilization	biological tist d order them view over mea ds in practical	sue. They can corresponding surement and applications
Skills	fields in biological tissue. In orc solutions of Maxwell's Equation models predict for biological tis and frequency, respectively, and develop validation strategies for	rious methods to characterize the ler to do this they can relate to and s. They are able to assess the mos ssue, they can order the effects c d they can analyze them in a quan or their predictions. They are abl peutic and diagnostic application	make use of t st important eff orresponding titative way. The to evaluate	he elementar ects that thes to wavelengt ney are able to the effects of
Personal Competence		ther on subject related tasks in sm	nall groups. Th	ey are able t
Social Competence	present their results effectively i	n English (e.g. during small group	exercises).	
Autonomy	relate that information to the obtined between their knowledge obtain of electromagnetic fields, fun	information from subject related, p context of the lecture. They are ned in this lecture with the content damentals of electrical enginee ects in the field of bioelectromagne	able to make of other lectur ring / physic	a connection es (e.g. theor s). They car
Workload in Hours	Independent Study Time 110, S	tudy Time in Lecture 70		

Examination	
Examination duration and scale	45 min
Assignment for the Following Curricula	Biomedical Engineering, Specialisation implants and Engoprostneses, Elective Compulsory

	ctromagnetics: Principles and Applications
Hrs/wk	
СР	
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language Cycle	
Oycle	- 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
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
Content	- 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
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CI
	(2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wi (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2004
	<ul> <li>F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagne Fields", CRC (2006)</li> </ul>

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

Module M0630: R	lobotics an	d Naviga	ation in Medici	ne		
Courses						
Title	- Madiaira (1.000)	-,		Тур	Hrs/wk	СР
Robotics and Navigation in Robotics and Navigation in				Lecture Project Seminar	2 2	3 2
Robotics and Navigation in				Recitation Section (small)	1	1
Module Responsible	Prof. Alexande	r Schlaefer				
Admission Requirements	None					
Recommended Previous Knowledge	<ul> <li>principl</li> </ul>		(algebra, analysis/ca amming, e.g., in Java kills	-		
Educational Objectives	After taking par	t successfu	lly, students have re	ached the following lea	rning resu	lts
Professional Competence						
Knowledge	systems and th	neir compoi safety and	nents in detail. Syst	cking systems in clinica tems can be evaluated its can assess typical sy	with respe	ect to collisi
Skills	medical applica		design and evalua	ate navigation systems	and robot	ic systems
Personal Competence	The students	discuss th	e results of other	r groups, provide hel	oful feedb	ack and c
Social Competence				groups, provide rich		
Autonomy			heir knowledge and ppropriate manner.	d document the results	of their w	ork. They c
Workload in Hours	Independent S	tudy Time 1	10, Study Time in Lo	ecture 70		
Credit points	6					
Course achievement		8 <b>onus</b> 0 % 0 %	<b>Form</b> Written elaboration Presentation	Descriptio	n	
Examination	Written exam					
Examination duration and scale	90 minutes					
	Electrical Engir International M Compulsory Mechatronics: Biomedical Eng Compulsory Biomedical Eng	neering: Sp lanagemen Specialisati gineering: S gineering: S	ecialisation Medical t and Engineering: S on Intelligent Syster Specialisation Artific Specialisation Implan	Engineering: Elective ( Technology: Elective ( Specialisation II. Electric ms and Robotics: Electiv ial Organs and Regene nts and Endoprostheses lical Technology and (	ompulsory cal Engine ve Compul rative Med s: Elective	, ering: Electi sory licine: Electi Compulsory

Assignment for the	Biomedical Engineering: Specialisation Management and Business Administration: Elective
Following Curricula	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 Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective
	Compulsory

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

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

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

## TUHH Hamburg University of Technology

Courses					
Title			Тур	Hrs/wk	СР
ntroduction into Medical	echnology and Systems (L	0342)	Lecture	2	3
ntroduction into Medical	echnology and Systems (L	0343)	Project Seminar	2	2
Introduction into Medical	echnology and Systems (L	1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaef	ər			
Admission Requirements	None				
	principles of math (algeb	ora, analysis/calculus	)		
Recommended	principles of stochastics				
Previous Knowledge	principles of programmin	ng, R/Matlab			
Educational Objectives	After taking part success	sfully, students have r	eached the following lea	Irning resul	lts
Professional					
Competence					
Knowledge	computer aided ourgony	, and medical inform	edical technology, inclu ation systems. They are technology.		
Skills		to evaluate systems	and medical devices i	in the cont	text of clinica
	applications.				
Personal					
Personal Competence		problem in medical	technology as a project,	and define	tasks that ar
Personal Competence Social Competence	The students describe a solved in a joint effort.	t their knowledge ar	nd document the results		
Personal Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect	t their knowledge ar appropriate manner.	nd document the results		
Personal Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge ar appropriate manner.	nd document the results		
Personal Competence Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge ar appropriate manner.	nd document the results	of their w	
Personal Competence Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus	t their knowledge ar appropriate manner. 110, Study Time in I	ecture 70	of their w	
Personal Competence Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus	t their knowledge ar appropriate manner. 110, Study Time in L Form	ecture 70	of their w	
Personal Competence Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 %	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboratio	ecture 70	of their w	
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboratio	ecture 70	of their w	
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination duration	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboration Presentation Science (German pro ry cialisation Computer	Description Description Description	of their w	ork. They ca
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering: C	t their knowledge ar appropriate manner. a 110, Study Time in L Form Written elaboration Presentation Science (German pro ry cialisation Computer Core qualification: Ele Science (English pro	Description Description Description	of their w	ork. They ca
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboration Presentation Presentation Science (German pro- ry cialisation Computer Core qualification: Ele Science (English pro- ry e and Engineering: ulsory	Description Description Description Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math	on pecialisatio ng: Elective pecialisatio nematics &	ork. They ca
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Science: Science	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboration Presentation Presentation Science (German pro- ry cialisation Computer Core qualification: Ele Science (English pro- ry e and Engineering: ulsory e and Engineering	Description Description Description Description n ogram, 7 semester): Sp and Software Engineerin octive Compulsory ogram, 7 semester): Sp Specialisation II. Math : Specialisation Comp	on pecialisation ng: Elective pecialisation nematics & puter Scie	ork. They ca
Personal Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Compulsory Computational Science Compulsory	t their knowledge ar appropriate manner. 110, Study Time in L Form Written elaboration Presentation Presentation Science (German pro- ry cialisation Computer Core qualification: Ele Science (English pro- ry e and Engineering: ulsory e and Engineering: and Engineering:	Description Description Description Description n ogram, 7 semester): Sp and Software Engineerin octive Compulsory ogram, 7 semester): Sp Specialisation II. Math : Specialisation Comp	of their w	ork. They ca

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

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

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

Courses							
<b>Title</b> Nonlinear Dynamics (L07	02)	<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6			
Module Responsible	Prof. Norbert Hoffmann						
Admission Requirements	None						
Recommended Previous Knowledge	<ul><li>Calculus</li><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>						
Educational Objectives	After taking part successfully, students ha	ve reached the following	learning resu	lts			
Professional Competence							
Knowledge	develop and research new terms and concepts.						
Skills	Students are able to apply existing meth develop novel methods and procedures.	ods and procesures of I	Nonlinear Dy	namics and			
Personal Competence							
-	Students can reach working results also i	n groups.					
Autonomy	Students are able to approach given res novel research tasks by themselves.	earch tasks individually a	nd to identify	and follow			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56					
Credit points	6						
Course achievement							
Examination	Written exam						
Examination duration and scale	2 Hours						
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory						

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

Courses							
Title		Тур	Hrs/wk	СР			
Semiconductor Technolog		Lecture	4	4			
Semiconductor Technolog		Practical Course	2	2			
	Prof. Hoc Khiem Trieu						
Admission Requirements	None						
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semiconductor devices						
Educational Objectives	After taking part successfully, students have reached the following learning results						
Professional Competence							
	Students are able						
	<ul> <li>to describe and to explain current fabrication techniques for Si and GaAs substrates,</li> </ul>						
Knowledge	<ul> <li>to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and</li> </ul>						
	to present integrated process t	flows.					
	Students are capable						
	<ul> <li>to analyze the impact of process parameters on the processing results,</li> </ul>						
Skills							
		e fabrication of semiconductor of	devices.				
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 front of audience.						
Autonomy	None						
	Independent Study Time 96, Study	y Time in Lecture 84					
Credit points							
Course achievement	None						
Examination	Oral exam						
Examination duration and scale	30 min						
and scale							

	Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
	Compulsory
Assignment for the	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
Following Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
·	Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective
	Compulsory

Course L0722: Semico	onductor Technology						
Тур	Lecture						
Hrs/wk	4						
СР	4						
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56						
Lecturer	Prof. Hoc Khiem Trieu						
Language	E/EN						
Cycle	SoSe						
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process)</li> <li>Wafer fabrication (process flow, specification, SOI)</li> <li>Fabrication processes</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>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 undercuting, compensation masks and etch stop techniques; dy etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> <li>Process integration (CMOS process, bipolar</li></ul>						

	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
Literature	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: Semico	ourse L0723: Semiconductor Technology					
Тур	Practical Course					
Hrs/wk	2					
СР	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					

Courses								
<b>Title</b> Humanoid Robotics (L066	3)				<b>Typ</b> Seminar		Hrs/wk 2	<b>CP</b> 2
Module Responsible	Patrick	Göttsch						
Admission	None							
Recommended Previous Knowledge			on to control leory and de	•				
Educational Objectives	After tal	king part s	successfully,	students h	ave reached th	e following le	earning resu	lts
Professional Competence								
Knowledge	<ul> <li>Students can explain humanoid robots.</li> <li>Students learn to apply basic control concepts for different tasks in humanoid robotics.</li> </ul>							
Skills	<ul> <li>Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature</li> <li>Students generalize developed results and present them to the participants</li> <li>Students practice to prepare and give a presentation</li> </ul>							
Personal Competence								
Social Competence	<ul> <li>Students are capable of developing solutions in interdisciplinary teams and presen them</li> <li>They are able to provide appropriate feedback and handle constructive criticism o their own results</li> </ul>							
Autonomy	<ul> <li>Students evaluate advantages and drawbacks of different forms of presentation fo specific tasks and select the best solution</li> <li>Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops</li> </ul>							
Workload in Hours	Indepe	ndent Stu	dy Time 32,	Study Time	in Lecture 28			
Credit points								
Course achievement								
Examination	Presen	tation						
Examination duration and scale	30 min							
Assignment for the	Mechatronics: Specialisation Intelligent Systems and Robotics: 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 Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Title Linear and Nonlinear System Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence	Prof. Herbert Werner	decomposition stic processes	Hrs/wk 2	CP 3
Admission Requirements Recommended Previous Knowledge Educational Objectives	<ul> <li>None</li> <li>Classical control (frequency restant of the system of the syste</li></ul>	decomposition stic processes	ring learning resu	Its
Recommended Previous Knowledge Educational Objectives Professional	<ul> <li>Classical control (frequency res</li> <li>State space methods</li> <li>Discrete-time systems</li> <li>Linear algebra, singular value</li> <li>Basic knowledge about stocha</li> </ul>	decomposition stic processes	ring learning resu	Its
Previous Knowledge Educational Objectives Professional	<ul> <li>State space methods</li> <li>Discrete-time systems</li> <li>Linear algebra, singular value</li> <li>Basic knowledge about stocha</li> </ul>	decomposition stic processes	ring learning resu	Its
Objectives <sup>/</sup> Professional	After taking part successfully, students	have reached the follow	ing learning resu	lts
Knowledge	<ul> <li>Students can explain the gen application to a variety of linear</li> <li>They can explain how multila dynamics</li> <li>They can explain how an app neural network models</li> <li>They can explain the idea of realisation theory</li> </ul>	r and nonlinear model st yer perceptron networks proximate predictive cor	ructures s are used to mo ntrol scheme can	odel nonline be based o
Skills	<ul> <li>Students are capable of applidentification of linear and nonl</li> <li>They are capable of implement neural network model</li> <li>They are capable of applying statistical for dynamic system</li> <li>They can do the above using Identification Toolbox)</li> </ul>	linear models for dynami nting a nonlinear predict subspace algorithms to th ems	c systems ive control schem he experimental io	ne based on dentification
Personal Competence				
Social Competence	Students can work in mixed groups on		-	
	Students are able to find required inf software documentation) and use it to	-	ovidea (lecture no	otes, literatur
Workload in Hours	Independent Study Time 62, Study Tim	ne in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			

	Mechatronics: Specialisation System Design: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
Following Curricula	Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses						
<b>Title</b> Optimal and Robust Conti	ol (L06	58)	<b>Typ</b> Lect		<b>Hrs/wk</b> 2	<b>СР</b> 3
Optimal and Robust Conti				tation Section (small)	2	3
Module Responsible		lerbert Werner				
Admission Requirements	None					
Recommended Previous Knowledge	•	Classical control (frequen State space methods Linear algebra, singular v				
Educational Objectives	After ta	aking part successfully, stuc	lents have reache	ed the following lea	rning resul	ts
Professional Competence						
Knowledge	• • • •	Students can explain the LQ problems. They can explain the d estimation. They can explain how the performance constraints. They can explain how an an H2 design problem. They can explain how mo to robust controller design They can explain how - guarantee stability and pe They understand how an represented as linear mat	uality between of H2 and H-infinit LQG design pro- odel uncertainty of pased on the sm rformance for an alysis and synthe	optimal state feed y norms are used t blem can be formu an be represented nall gain theorem - uncertain plant.	back and to represen lated as sp in a way th a robust	optimal sta nt stability an pecial case nat lends itse controller ca
Skills	<ul> <li>Students are capable of designing and tuning LQG controllers for multivariable models.</li> <li>They are capable of representing a H2 or H-infinity design problem in the forr generalized plant, and of using standard software tools for solving it.</li> <li>They are capable of translating time and frequency domain specifications for cloops into constraints on closed-loop sensitivity functions, and of carrying out a r sensitivity design.</li> <li>They are capable of constructing an LFT uncertainty model for an uncertain stand of designing a mixed-objective robust controller.</li> <li>They are capable of formulating analysis and synthesis conditions as linear inequalities (LMI), and of using standard LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust ot toolbox).</li> </ul>		the form of ons for contr g out a mixe ertain syste linear mat			
Personal Competence						
Social Competence		nts can work in small group		-		
Autonomy		nts are able to find require are documentation) and use			(iecture no	ites, literatu

Workload in Hours
Credit points
Course achievement
Examination
Examination duration and scale
Assignment for the Following Curricula

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

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

Courses						
<b>Title</b> Marketing of Innovations (	L2009)		<b>Typ</b> Lecture		Hrs/wk 4	<b>CP</b> 4
PBL Marketing of Innovations (L0862)			Project-/problem- Learning	based	1	2
Module Responsible	Prof. C	hristian Lüthje				
Admission Requirements	None					
Recommended Previous Knowledge	•	Module International Business Basic understanding of busine theory, project management, i Bachelor-level Marketing Kno Strategies, Basics of Buying B Unerstanding the differences Understanding of the importan Good English proficiency; pre	ess administration princip nternational business) weledge (Marketing Instru- ehavior) beweetn B2B and B2C m nce of managing innovation	uments arketin	s, Market ar ng	nd Competi
Educational Objectives	After ta	aking part successfully, student	s have reached the follow	ving lea	arning resul	ts
Professional Competence						
Knowledge	• • • • • •	nts will have gained a deep un Specific characteristics in the Approaches for analyzing development The gathering of information a Concepts and approaches to service development processo Approaches and tools for en products and innovative servic Marketing mix elements that challenges of innovative prod Pricing methods for new product The organization of complex s	marketing of innovative p the current market situ bout future customer nee integrate lead users an es suring customer-orientat ces take into consideration ucts and services ucts and services ales forces and personal instruments for new proc	ds and d their on in the sp selling	and the f d requireme r needs into the develop pecific requ	future mark nts p product a pment of ne irements a
Skills	• • • •	on the acquired knowledge stu Design and to evaluate decisi Analyze markets by applying a Conduct forecasts and develo Translate customer needs is successfully apply advanced development Use adequate methods to fost Choose suitable pricing strate Make strategic sales decisio channels) Apply methods of sales force in	ons regarding marketing market and technology po p compelling scenarios a nto concepts, prototype d methods for customer er efficient diffusion of inr gies and communication ons for products and se	ortfolios s a ba s and c-orient novativ activiti ervices	s sis for strate I marketabl ted product re products a es for innov s (i.e. selec	egic plannin le offers a t and servi and service rations

Social Competence	<ul> <li>have fruitful discussions and exchange arguments</li> <li>develop original results in a group</li> <li>present results in a clear and concise way</li> <li>carry out respectful team work</li> </ul>
Autonomy	<ul> <li>The students will be able to</li> <li>Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields.</li> <li>Consider proposed business actions in the field of marketing and reflect on them.</li> </ul>
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration exercises presentation oral participation
Assignment for the Following Curricula	<ul> <li>Global Technology and Innovation Management &amp; Entrepreneurship: Core qualification: Compulsory</li> <li>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory</li> <li>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Management and Business Administration: Compulsory</li> </ul>

TUHH

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

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

Module M1143: N	lechanical Design Me	thodology		
Courses				
<b>Title</b> Mechanical Design Metho Mechanical Design Metho		<b>Typ</b> Lecture Recitation S	Hrs/wk 3 ection (small) 1	<b>CP</b> 4 2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	students have reached the f	ollowing learning res	ults
Professional Competence Knowledge	Science-based working on pi design techniques	oduct design considering ta	rgeted application of s	specific produc
Skills	Creative handling of proces product design problems / theoretical aspects.			
Personal Competence				
Social Competence				
Autonomy				
	Independent Study Time 124	, Study Time in Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula				

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

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

Courses					
Title		Ту	p	Hrs/wk	СР
Bioprocess Engineering -	Fundamentals (L0841)	-	cture	2	3
Bioprocess Engineering- I			citation Section (large)	2	1
	Fundamental Practical Course (L084	-3) Pra	actical Course	2	2
Module Responsible					
Admission Requirements					
Recommended Previous Knowledge	none, module "organic chemistry	y", module "funda	mentals for process	engineerir	ıg"
Educational Objectives	After taking part successfully, stu	idents have react	ned the following lea	rning resul	lts
Professional Competence					
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.				
Skills	<ul> <li>After successful completion of this module, students should be able to</li> <li>describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters</li> <li>predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process</li> <li>analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations</li> <li>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</li> <li>propose solutions to complicated biotechnological problems and to deduce the corresponding models</li> <li>to explore new knowledge resources and to apply the newly gained contents</li> <li>identify scientific problems with concrete industrial use and to formulate solutions.</li> </ul>				
Personal Competence	After completion of this module	participants sho	uld be able to deba	te technica	I questions
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase the capacity for teamwork in engineering and scientific environments.				
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.				
Workload in Hours	Independent Study Time 96, Stud	dy Time in Lectur	re 84		
Credit points	6				

	practical work		
	Written exam		
Examination duration and scale	90 min		
-	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, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: 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 Process Engineering: Core qualification: Compulsory		

Ture		
Hrs/wk		
СР		
	Independent Study Time 62, Study Time in Lecture 28	
	Prof. Andreas Liese, Prof. An-Ping Zeng	
Language		
Cycle	SoSe	
Content	<ul> <li>Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese)</li> <li>Transport process in a bioreactor (Prof. Zeng)</li> <li>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fe batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese)</li> <li>Downstream technology in biotechnology: cell breakdown, zentrifugation, filtratic aqueous two phase systems (Prof. Liese)</li> </ul>	
Literature	<ul> <li>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wild VCH, 2012</li> <li>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</li> <li>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Pre 2010</li> <li>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor &amp; Francis, 1997</li> <li>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</li> </ul>	

Course L0842: Bioprocess Engineering- Fundamentals		
Тур	Recitation Section (large)	
Hrs/wk		
СР		
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	<ol> <li>Introduction (Prof. Liese, Prof. Zeng)</li> <li>Enzymatic kinetics (Prof. Liese)</li> <li>Stoichiometry I + II (Prof. Liese)</li> <li>Microbial Kinetics I+II (Prof. Zeng)</li> <li>Rheology (Prof. Liese)</li> <li>Mass transfer in bioprocess (Prof. Zeng)</li> <li>Continuous culture (Chemostat) (Prof. Zeng)</li> <li>Sterilisation (Prof. Zeng)</li> <li>Downstream processing (Prof. Liese)</li> <li>Repetition (Reserve) (Prof. Liese, Prof. Zeng)</li> </ol>	
Literatura	siehe Vorlesung	
Literature	siene vonesung	

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

Courses				
Title htroduction to Physiology	(L0385)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students ha	ive reached the follow	ving learning resul	ts
Professional Competence				
	The students can			
Knowledge	<ul> <li>describe the basics of the energy metabolism;</li> <li>describe physiological relations in selected fields of muscle, heart/circulation, neurand sensory physiology.</li> </ul>			
Skills	The students can describe the effects of processing of information, development of technical systems.	•	· ·	
Personal Competence				
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical a metrological.			
Autonomy	The students can derive answers to questions arising in the course and other physiologic areas, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination				
Examination duration and scale	60 minutes			
Assignment for the Following Curricula	General Engineering Science (German Engineering: Compulsory General Engineering Science (German Engineering, Focus Biomechanics: Comp Electrical Engineering: Specialisation Me General Engineering Science (English Engineering, Focus Biomechanics: Comp General Engineering Science (English Engineering: Compulsory Mechanical Engineering: Specialisation Biomedical Engineering: Specialisation	program, 7 semest oulsory edical Technology: Ele program, 7 semest oulsory program, 7 semest Biomechanics: Compu	ter): Specialisation ective Compulsory er): Specialisation ter): Specialisatio ulsory	n Mechanie n Mechanie n Biomedie

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

IED Is Introduction to Arctony			
IED I: Introduction to Anatomy			
.0384) Typ Lectur		<b>Hrs/wk</b> 2	<b>CP</b> 3
Prof. Udo Schumacher			
None			
None			
After taking part successfully, students have reached	the following lear	rning results	3
musculoskeletal system.		-	
The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explain the relevance of structures and their functions in the context of widespread diseases.			
The students can participate in current discussions in biomedical research and medicine on a professional level.			
The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the relevant knowledge themselves.			
Independent Study Time 62, Study Time in Lecture 2	8		
3			
None			
Written exam			
90 minutes			
General Engineering Science (German program, 7 semester): Specialisation Biomedica Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
	0384)       Lectur         Prof. Udo Schumacher	Typ           0384)         Lecture           Prof. Udo Schumacher         None           None	Typ         Hrs/wk           0384)         Lecture         2           Prof. Udo Schumacher         None

Course L0384: Introdu	ction to Anatomy		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Tobias Lange		
Language			
Cycle			
Content	2 <sup>nd</sup> week: T 3 <sup>rd</sup> week: C 4 <sup>th</sup> week: M 5 <sup>th</sup> week: C 6 <sup>th</sup> week: R	ne Eucaryote Cell he Tissues ell Cycle, Basics in Development usculoskeletal System ardiovascular System espiratory System enito-urinary System	
Content	9 <sup>th</sup> week: D 10 <sup>th</sup> week: D 11 <sup>th</sup> week: E 12 <sup>th</sup> week: N	igestive System I igestive System II indocrine System ervous System xam	
Literature	Adolf Faller/Micha Stuttgart, 2012	el Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verla	

Courses				
Fitle ntroduction to Radiology a	and Radiation Therapy (L0383)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ving learning resu	lts
Professional Competence				
	<b>Therapy</b> The students can distinguish differe in radiation therapy.	nt types of currently used o	equipment with res	spect to its u
	The students can explain treatme contexts (e.g. surgery, internal medi	-	ion therapy in in	terdisciplina
	The students can describe the pa follow-up care.	tients' passage from the	ir initial admittan	ce through
	Diagnostics			
Knowledge	The students can illustrate the tech angiography and mammography, as			
	The students can explain the diagn well as the technical basis for those	•	c use of imaging t	echniques,
	The students can choose the right tr and needs.	eatment method dependir	ng on the patient's	clinical histo
	The student can explain the influence	ce of technical errors on th	e imaging techniqi	ues.
	The student can draw the right cor error protocol.	clusions based on the im	ages' diagnostic f	indings or t
	<b>Therapy</b> The students can distinguish curativ that conclusion.	ve and palliative situations	and motivate why	r they came
	The students can develop adequate aspects.	e therapy concepts and re	late it to the radia	tion biologic
	The students can use the therapeut	c principle (effects vs adve	erse effects)	
Skills	The students can distinguish differe on the situation (location of the t (irradiation planning).			•
	The student can assess what an ine up treatment, sports, social help gro			
	Diagnostics			
	The students can suggest solutions	s for repairs of imaging in	strumentation afte	r having do

	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.
Personal Competence	
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine. The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.
	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	None
	Written exam
Examination duration and scale	90 minutes
-	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, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introdu	ction to Radiology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments

Literature	<ul> <li>"Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999</li> <li>"Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –</li> <li>4. Auflage - Verlag Urban &amp; Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1</li> <li>"Strahlentherapie und Onkologie für MTA-R" von R. Sauer – 5. Auflage 2003 - Verlag Urban &amp; Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6</li> <li>"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus 8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8</li> <li>"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</li> <li>"Praxismanual Strahlentherapie" von Stöver / Feyer – 1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000</li> </ul>



Module M1332: B	BIO I: Experimental Methods	in Biomechanics		
Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in I	Biomechanics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate " "Experimentelle Methoden".	in "Implantate und Fra	kturheilung" bef	ore attendin
Educational Objectives	After taking part successfully, students	have reached the followi	ng learning resu	lts
Professional Competence				
Knowledge	The students can describe the difference. The students can name different tre fracture morphologies. The students can describe different m choose the adequate technique for a g	atments for the spine an easurement techniques t	nd hollow bones	s under give
Skills	The students can describe the basic biomechanics.	handling of several exp	perimental techn	iques used i
Personal Competence				
Social Competence	The students can, in groups, solve bas	sic experimental tasks.		
Autonomy	The students can, in groups, solve bas	sic experimental tasks.		
Workload in Hours	Independent Study Time 62, Study Tin	ne in Lecture 28		
Credit points				
Course achievement				
Examination Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (Germ Engineering, Focus Biomechanics: Co General Engineering Science (Germ Engineering: Compulsory General Engineering Science (Engl Engineering, Focus Biomechanics: Co General Engineering Science (Engl Engineering: Compulsory	ompulsory nan program, 7 semeste ish program, 7 semeste ompulsory ish program, 7 semeste on Biomechanics: Compu on Artificial Organs and R on Implants and Endopros on Medical Technology on Management and Bu	er): Specialisatio er): Specialisatio er): Specialisatio lsory egenerative Med and Control Th siness Administr	on Biomedica n Mechanica on Biomedica licine: Electiv Compulsory eory: Electiv ation: Electiv

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

Module M1335: B	BIO II: Artificial Joint Re	placement		
Courses				
<b>Title</b> Artificial Joint Replacemer	nt (L1306)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic	and surgical techniques is recor	mmended.	
Educational Objectives	After taking part successfully, s	tudents have reached the followi	ng learning resul	ts
Professional Competence				
Knowledge	The students can name the diff	erent kinds of artificial limbs.		
Skills	The students can explain endoprotheses.	the advantages and disadva	ntages of differ	ent kinds of
Personal Competence				
Social Competence		iss issues related to endoprothe	se with student r	nates and the
Autonomy	The students are able to acquir with respect to its credibility.	re information on their own. They	can also judge tl	ne information
Workload in Hours	Independent Study Time 62, St	udy Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering an Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Drientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		ory icine: Elective ory eory: Elective ation: Elective	

ourse L1306: Artifici	al Joint Replacement	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Michael Morlock	
Language		
Cycle		
	Inhalt (deutsch)	
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker satzes)	
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)	
	<ol> <li>DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannensein Evolution der Implantate)</li> </ol>	
Content	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)	
	Literatur:	
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.	
Literature	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&Febige Philadelphia, 1989.	
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.	
	Sobotta und Netter für Anatomie der Gelenke	

Module M0845: F	eedback Control in Medi	cal Technology			
Courses					
Title Feedback Control in Medi	cal Technology (L0664)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3	
Module Responsible	Johannes Kreuzer				
Admission Requirements	None				
Recommended Previous Knowledge	Basics in Control, Basics in Physic	blogy			
Educational Objectives	After taking part successfully, stud	ents have reached the followi	ng learning resul	ts	
Professional Competence					
	The lecture will introduce into the point of view. Fundamentals in hu in control theory.	-			
Knowledge	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system fo example in for anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.				
Skills	Application of modeling, identification, control technology in the field of medical technology.				
Personal					
Competence					
Social Competence	Students can develop solutions to	specific problems in small gro	oups and presen	t their results	
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.				
Workload in Hours	Independent Study Time 62, Stud	y Time in Lecture 28			
Credit points					
Course achievement	l				
Examination					
Examination duration and scale	20 min				
Assignment for the Following Curricula	I Riomodical Engineering. Specialization Artiticial Chaste and Regenerative Medicine. Flectiv				
	Biomedical Engineering: Speciali	sation Medical Technology an	d Control Theory	: Compulsory	

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

## Module M0832: Advanced Topics in Control

Title		Тур	Hrs/wk	СР
Advanced Topics in Contr	ol (L0661)	Lecture	2	3
Advanced Topics in Contr	ol (L0662)	Recitation Section (small)	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-s	sensitivity design, linear matrix inequa	alities	
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
	<ul> <li>scheduling approach</li> <li>They can explain the repsystems</li> <li>They can explain how st formulated as LMI condition</li> <li>They can explain how synthesis problems for LF</li> <li>They are familiar with pole</li> </ul>	gridding techniques can be used	n the form for LPV sy to solve PV systema	of quasi-LP vstems can b analysis an s and some o
Knowledge	<ul><li>communication topology</li><li>They can explain the con-</li></ul>	vergence properties of first order cor ysis and synthesis conditions for	isensus pr	otocols
	<ul><li>systems that are discretize</li><li>They can explain (in or</li></ul>	e state space representation of spati ed according to an actuator/sensor a utline) the extension of the bound he associated synthesis conditions fo	rray ed real le	mma to suc
	mixed-sensitivity design polytopic, LFT or general	constructing LPV models of nonlinea of gain-scheduled controllers; th LPV models ndard software tools (Matlab robust o	ey can c	do this usir
Skills		ign distributed formation controllers f cs, using Matlab tools provided	or groups	of agents wi
	<ul> <li>Students are able to design using the Matlab MD-tool</li> </ul>	gn distributed controllers for spatially	interconne	ected system

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Attificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Attificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0661: Advance	ced Topics in Control		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling         <ul> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> </ul> </li> <li>Control of Multi-Agent Systems         <ul> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> </ul> </li> <li>Control of Spatially Interconnected Systems         <ul> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Multidimensional systems in Roesser state space form</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul> </li> </ul>		
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>		

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

## Specialization Artificial Organs and Regenerative Medicine

Module M0623: Ir	ntelligent Systems i	n Medicine			
Courses					
Title	(L000.4)		Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331) Intelligent Systems in Medicine (L0334)			Lecture Project Seminar	2 2	3 2
Intelligent Systems in Med			Recitation Section (small)	_	1
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous Knowledge	P - P	astics amming, Java/C++ a			
Educational Objectives	After taking part successfu	lly, students have re	eached the following lea	arning resul	Its
Professional					
Competence					
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
Skills	The students can give regression, and prediction evaluate the implemented	n. They can assess			
Personal Competence					
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.				
Autonomy	The students can reflect t present the results in an ap	-	d document the results	s of their w	ork. They can
Workload in Hours	Independent Study Time 1	10, Study Time in L	ecture 70		
Credit points	6				
Course achievement	Yes 10 %	Form Written elaboration Presentation	Descriptio	n	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Specia Electrical Engineering: Sp Computational Science ar Elective Compulsory	ecialisation Medical	Technology: Elective C	Compulsory	,

	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0331: Intelligent Systems in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>	
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: Intellige	Course L0334: Intelligent Systems in Medicine	
Тур	Project Seminar	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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

#### TUHH

# Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Title		Тур	Hrs/wk	СР
Intelligent Autonomous Agents and Cognitive Robotics (L0341)		Lecture	2	4
Intelligent Autonomous Ag	ents and Cognitive Robotics (L0512)	Recitation Section (sma	ll) 2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students I	have reached the following le	arning resu	Its
Professional				
Competence				
Knowledge	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 identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. 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.			
Skills	Students can select an appropriate scenarios. For simplified agent applicat optimization techniques. For those networks/dynamic Bayesian networks Students can also name and apply scenarios. For simple and complex der policies for concrete settings. In multi finding different equilibria states,e.g. students will apply different voting prote	tion students can derive decise applications they can and apply bayesian reaso different sampling techniq cision making students can o ti-agent situations students , Nash equilibria. For multi-	sion trees at also creationing for si ues for sin compute the will apply t ti-agent dec	nd apply basi ate Bayesia mple queries nplified ager best action o echniques fo cision makin
Personal Competence				
Social Competence	Students are able to discuss their sol English	utions to problems with othe	ers. They co	ommunicate i
Autonomy	Students are able of checking their und concrete problems	derstanding of complex conc	epts by solv	ing varaints c
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56		
Credit points	6			
	Nono			
Course achievement	None			
Course achievement Examination				

and scale	
-	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: 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 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0341: Intellige	ent Autonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul> <li>Definition of agents, rational behavior, goals, utilities, environment types</li> <li>Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minima algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty: Motivation: agents with no direct access to the state(s) of the environmen probabilities, conditional probabilities, product rule, Bayes rule, full joint probabilit distribution, marginalization, summing out, answering queries, complexity independence assumptions, naive Bayes, conditional independence assumptions</li> <li>Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference b enumeration), typical-case complexity, pragmatics: reasoning from effect (that can b perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynami 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</li> <li>Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration MDPs</li> <li>Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs dynamic decision networks</li> <li>Simultaneous Localization and Mapping</li> <li>Planning</li> <li>Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium</li> <li>Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem,</li> <li>Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard Satterthwaite Impossibility Theorem, Direct mechanisms, expected externalit mechanisms, p</li></ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17</li> <li>Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005</li> <li>Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoa Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009</li> </ol>

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

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

Courses			
Title	Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	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

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

Course L1669: Introdu	ction to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Most important types of waveguides and their properties</li> <li>Radiation and basic antenna parameters</li> <li>Most important types of antennas and their properties</li> <li>Numerical techniques and CAD tools for waveguide and antenna design</li> <li>Fundamentals of Electromagnetic Compatibility</li> <li>Coupling mechanisms and countermeasures</li> <li>Shielding, grounding, filtering</li> <li>Standards and regulations</li> <li>EMC measurement techniques</li> </ul>
Literature	<ul> <li>Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

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

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

Course L1580: Experimental Methods for the Characterization of Materials	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 min
Lecturer	Prof. Patrick Huber
Language	DE
Cycle	SoSe
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>
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: Numer	ical Methods in Biomechanics
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Vorkenntnisse aus "Diskretisierungsmethoden der Mechanik" sind empfohlen</li> <li>Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt.</li> <li>Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten</li> <li>Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden</li> <li>Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt.</li> <li>Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.</li> </ul>
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L1130: Six Sig	ma	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale		
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>	
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 M	echanics II
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>

Course L1820: System	n Simulation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	'30 min	
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>	
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>	

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

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

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

Courses			
Title	Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	I Riomodical Endingering. Specialisation Management and Rijsinges Administration. Flectivel

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

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

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

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

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

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

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

Course L1130: Six Sig	ma		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale	90 Minuten		
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>		
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 M	echanics II			
Typ Lecture				
Hrs/wk	2			
СР	4			
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28			
Examination Form	lausur			
Examination duration and scale				
Lecturer	Prof. Michael Schlüter			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>			
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>			

Course L1820: System Simulation			
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale	'30 min		
Lecturer	Dr. Stefan Wischhusen		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>		
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>		

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

Course L0379: Ceramics Technology			
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form			
Examination duration and scale	90 Minuten		
Lecturer	Dr. Rolf Janßen		
Language			
Cycle	WiSe		
	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder-based processing, e.g. "powder-metauurgica techniques and sintering (soild state and liquid phase). Also, some aspects of glass 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	
Content		3. Powder fabrication	
		4. Powder processing	
		5. Shape-forming processes	
		6. Densification, sintering	
		7. Glass and Cement technology	
		8. Ceramic-metal joining techniques	
	W.D. Kingery, "Introduction	to Ceramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials	Handbook Vol.4 "Ceramics and Glasses", 1991	
Literature	D.W. Richerson, "Modern C	eramic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

Module M0746: N		<b>.</b>			
Courses					
<b>Title</b> Microsystem Engineering	(L0680)		<b>Typ</b> Lecture	<b>Hrs/wk</b> 2	<b>CP</b> 4
Microsystem Engineering	(L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	None				
Recommended Previous Knowledge	Racio courcos in physica	s, mathematics and el	ectric engineering		
Educational Objectives	After taking part success	fully, students have re	eached the following lea	arning resul	ts
Professional Competence					
-	The students know about their applications in sense		technologies and mate	rials of ME	MS as well
Skills	Students are able to ana to evaluate the potential		e functional behaviour o	f MEMS co	mponents a
Personal Competence					
Social Competence	Students are able to so	lve specific problems			
	accordingly.		aione or in a group a	nd to prese	ent the resu
	accordingly. Students are able to acc and associate this know	uire particular knowle	edge using specialized	·	
Autonomy	Students are able to acc	uire particular knowle ledge with other fields	edge using specialized l s.	·	
Autonomy	Students are able to acc and associate this know Independent Study Time	uire particular knowle ledge with other fields	edge using specialized l s.	·	
Autonomy Workload in Hours Credit points	Students are able to acc and associate this know Independent Study Time	uire particular knowle ledge with other fields	edge using specialized l s.	literature a	
Autonomy Workload in Hours Credit points Course achievement	Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus	uire particular knowle ledge with other fields a 124, Study Time in L Form	edge using specialized i s. ecture 56	literature a	
Autonomy Workload in Hours Credit points Course achievement	Students are able to acc and associate this know Independent Study Time 6 Compulsory Bonus No 10 % Written exam	uire particular knowle ledge with other fields a 124, Study Time in L <b>Form</b> Presentation	edge using specialized l s. .ecture 56 <b>Descriptic</b>	literature a	



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0680: Micros	ystem Engineering
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Manfred Kasper
Language	
Cycle	
	Object and goal of MEMS Scaling Rules Lithography Film deposition Structuring and etching Energy conversion and force generation Electromagnetic Actuators
Content	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	Typ Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
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	

Module M0751: V	ibration Theory			
Courses				
<b>Title</b> Vibration Theory (L0701)	TypHrs/wkCPIntegrated Lecture46			
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	• Linear Algebra			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them furthe			
Skills	Students are able to denote methods of Vibration Theory and develop them further.			
Personal Competence				
-	I Students can reach working results also in groups.			
	Students are able to approach individually research tasks in Vibration Theory.			
	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	12 Hours			
-	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulso Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

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

#### TUHH Hamburg University of Technology

Courses						
<b>Fitle</b> Microsystems Technology	v (1 0794)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 4		
Microsystems Technology (L0724)		Project-/problem-ba	- heed			
Nicrosystems Technology	y (L0725)	Learning	2	2		
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous Knowledge	Basics in physics, chemistry, mechar	nics and semiconductor tech	nnology			
Educational Objectives	After taking part successfully, student	ts have reached the followir	ng learning res	ults		
Professional						
Competence						
	Students are able					
	<ul> <li>to present and to explain current methods for the fabrication of micro thereof in more complex systems</li> </ul>	•		•		
Knowledge	<ul> <li>to explain in details operation principles of microsensors and microactuators and</li> </ul>					
	• to discuss the potential and limitation of microsystems in application.					
	<ul><li>Students are capable</li><li>to analyze the feasibility of micros</li><li>to develop process flows for the factors</li></ul>		s and			
Skills	<ul> <li>to apply them.</li> </ul>					
Personal Competence						
	Students are able to prepare and p present and discuss the results in fro		nts in team wor	rk as well as t		
Autonomy	None					
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56				
Credit points	6					
-						



Course achievement	Yes None	Subject theoretical practical work	and durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebniise ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination			
Examination duration and scale	30 min		
Assignment for the Following Curricula	Elective Compulsory Electrical Engineering: Computational Science Elective Compulsory International Manager Compulsory Biomedical Engineering Compulsory Biomedical Engineering Biomedical Engineering Compulsory Biomedical Engineering Compulsory	Specialisation Medical Techn and Engineering: Specialis ment and Engineering: S g: Specialisation Artificial Org g: Specialisation Implants and g: Specialisation Medical T	ation Systems Engineering and Robotics: pecialisation II. Mechatronics: Elective gans and Regenerative Medicine: Elective d Endoprostheses: Elective Compulsory echnology and Control Theory: Elective ent and Business Administration: Elective

Course L0724: Microsy	ystems Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul> <li>Introduction (historical view, scientific and economic relevance, scaling laws)</li> <li>Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive; angular rate sensor: operating principle and fabrication process)</li> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR,</li> </ul>

	<ul> <li>fluxgate magnetometer)</li> <li>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)</li> <li>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)</li> <li>MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration)</li> <li>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)</li> <li>System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>
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: Micros	Course L0725: Microsystems Technology	
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Hoc Khiem Trieu	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

#### TUHH Hamburg University of Technology

ourses				
ïtle		Тур	Hrs/wk	СР
echnology Management	(L0849)	Project-/problem-based Learning	3	3
echnology Management	Seminar (L0850)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business mai	nagement		
Educational Objectives	After taking part successfully, student	s have reached the following lea	arning resu	lts
Professional				
Competence	Students will gain deep insights into:			
Knowledge	<ul> <li>Technology Timing Strategies         <ul> <li>Technology Strategies and Lifecycle Management (I/II)</li> <li>Technology Intelligence and Planning</li> </ul> </li> <li>Technology Portfolio Management         <ul> <li>Technology Portfolio Methodology</li> <li>Technology Acquisition and Exploitation</li> <li>IP Management</li> </ul> </li> <li>Organizing Technology Development         <ul> <li>Technology Organization &amp; Management</li> <li>Technology Funding &amp; Controlling</li> </ul> </li> </ul>			
Skills	<ul> <li>Foster a strategic orientation as Technology Management as Clarify activities of Technology and exploitation)</li> <li>Strengthen essential communic organizational and financial management. Further topics to</li> <li>Basic concepts, models and and innovation</li> </ul>	hal level understanding of important e ational, organizational and proc to problem-solving within the in and its importance for corporate gy Management (e.g. technolog nication skills and a basic under issues concerning Technology o be discussed include: tools, relevant to the manager	lements o ess-related novation pr strategy y sourcing erstanding o -, Innovatio	f Technolog aspects) rocess as we , maintenanc of manageria on- and R&E
Personal Competence	<ul> <li>Innovation as a process (step</li> </ul>	s, activities and results)		
Social Competence	<ul><li>Interact within a team</li><li>Raise awareness for globabl</li></ul>	issues		

Autonomy	<ul> <li>Discuss recent research debates in the context of Technology and Innovation Management</li> <li>Develop presentation skills</li> <li>Discussion of international cases in R&amp;D-Management</li> </ul>			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

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

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

Courses						
<b>Fitle</b> Control Systems Theory a Control Systems Theory a			<b>Typ</b> Lecture Recitation Section	2	s/wk	<b>CP</b> 4 2
Module Responsible		rner				
Admission Requirements						
Recommended Previous Knowledge		ontrol Systems				
Educational Objectives	After taking part s	successfully, students	have reached the follow	ing learnir	ng resul	ts
Professional Competence						
Knowledge	<ul> <li>Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space</li> <li>They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively</li> <li>They can explain the significance of a minimal realisation</li> <li>They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain state space models and transfer function models of discrete-time systems</li> <li>They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation</li> <li>They can explain how a state space model can be constructed from a discrete-time impulse response</li> </ul>					
Skills	versa They can They can They ca domain, a They can from expe They can	assess controllability design LQG controlle n carry out a contro and decide which is a identify transfer funct erimental data	fer function models into and observability and co ers for multivariable plants oller design both in con appropriate for a given sa ion models and state spa tasks using standard s Toolbox, Simulink)	onstruct mi s tinuous-tin mpling rat ace model	nimal re ne and e s of dyn	ealisations discrete-tin amic syster
Personal Competence						
Social Competence	Students can wor	rk in small groups on	specific problems to arriv	e at joint s	olution	S.
			from provided sourc nd use it when solving giv	•		es, softwa
Autonomy	They can assess progress.	s their knowledge in	weekly on-line tests and	thereby	control	their learnir

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: 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: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

Course L0656: Control Systems Theory and Design				
Тур	Lecture			
Hrs/wk	2			
СР				
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 systems difference equations and z-transform East squares estimation, ARX models, persistent excitation Identification and model order reduction Least squares estimation, ARX models, persistent excitation Balanced realization and model order reduction Case study Mudelling and multivariable control of a process evaporator using Matlab and Simulink Software tools Matlab/Simulink			
Literature	<ul> <li>Werner, H., Lecture Notes "Control Systems Theory and Design"</li> <li>T. Kailath "Linear Systems", Prentice Hall, 1980</li> <li>K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997</li> <li>L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999</li> </ul>			

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

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roduction Planning & Contro	l and Digital Enterpri	se	
5	5 1		
	Τνρ	Hrs/wk	СР
932)	Lecture	2	2
ontrol (L0929)	Lecture	2	2
			1
rprise (L0933)	Recitation Section (small)	) 1	1
Prof. Hermann Lödding			
None			
Fundamentals of Production and Quality	Management		
After taking part successfully, students h	ave reached the following lea	arning resul	Ite
	ave reached the following let		
Students can explain the contents of the	module in detail and take a c	ritical posit	ion to them.
Students are capable of choosing and		•	
Students can develop joint solutions in r	nixed teams and present ther	n to others.	
-			
Independent Study Time 96, Study Time	in Lecture 84		
6			
None			
Written exam			
180 Minuten			
International Management and Engine	eering: Specialisation II. Pro	oduct Deve	elopment and
Production: Elective Compulsory			
Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective			
Compulsory			
	i Medical Technology and	Control In	eory. Elective
	ion Management and B	usiness A	Administration:
Compulsory			
	Production: Specialisation	Product	Development:
	duction: Specialisation Prod	uction: Con	npulsory
Product Development, Materials an	•		
Compulsory			
, ,	chnical Complementary Cou	rse: Electiv	e Compulsory
	<ul> <li>32)</li> <li>ontrol (L0929)</li> <li>ontrol (L0930)</li> <li>prise (L0933)</li> <li>Prof. Hermann Lödding</li> <li>None</li> <li>Fundamentals of Production and Quality</li> <li>After taking part successfully, students h</li> <li>Students can explain the contents of the</li> <li>Students are capable of choosing and industrial problems.</li> <li>Students can develop joint solutions in n</li> <li>Independent Study Time 96, Study Time 6</li> <li>None</li> <li>Written exam</li> <li>180 Minuten</li> <li>International Management and Engine Production: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Compulsory</li> <li>Biomedical Engineering: Specialisation Compulsory</li> <li>Biomedical Engineering: Specialisation Compulsory</li> <li>Product Development, Materials and Product Development, Materials and Product Development, Materials and Product Development, Materials and Compulsory</li> <li>Product Development, Materials and Product Development, Materials and</li></ul>	Typ           32)         Lecture           ontrol (L0929)         Lecture           ontrol (L0930)         Recitation Section (small)           prise (L0933)         Recitation Section (small)           Prof. Hermann Lödding         None           Fundamentals of Production and Quality Management         After taking part successfully, students have reached the following lead           Students can explain the contents of the module in detail and take a construction of the second students are capable of choosing and applying models and metric industrial problems.           Students can develop joint solutions in mixed teams and present ther -           Independent Study Time 96, Study Time in Lecture 84           6           None           Written exam           180 Minuten           International Management and Engineering: Specialisation II. ProProduction: Elective Compulsory           Logistics, Infrastructure and Mobility: Specialisation Production Compulsory           Biomedical Engineering: Specialisation Implants and Endoprosthese           Biomedical Engineering: Specialisation Management and B           Compulsory           Biomedical Engineering: Specialisation Management and B           Compulsory           Biomedical Engineering: Specialisation Management and B           Compulsory           Biomedical Engineering: Specialisation Manage	32)       Lecture       2         ontrol (L0929)       Lecture       2         ontrol (L0930)       Recitation Section (small)       1         prise (L0933)       Recitation Section (small)       1         Prof. Hermann Lödding       None

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

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

Course L0930: Production Planning and Control	
Тур	Recitation Section (small)
Hrs/wk	1
СР	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: Exercis	course L0933: Exercise: The Digital Enterprise		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Axel Friedewald		
Language	DE		
Cycle			
Content	See interlocking course		
Literature	Siehe korrespondierende Vorlesung See interlocking course		

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Module M0921: E	Electronic Circuits for Medical	Applications		
Courses				
	edical Applications (L0696)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
	edical Applications (L1056) edical Applications (L1408)	Recitation Section ( Practical Course	small) 1 1	2 1
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	Nono			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully students ha	ave reached the followin	g learning resu	lts
Professional Competence				
Knowledge	<ul> <li>Students can explain the basic for nervous system</li> <li>Students are able to explain the along an axon</li> <li>Students can exemplify the comm</li> <li>Students can describe the spon applications</li> <li>Students can explain the function</li> <li>Students are able to discuss the artificial eyes</li> </ul>	e build-up of an action nunication between neur ecial features of low-r s of prostheses, e. g. an	potential and it rons and electro noise amplifier artificial hand	s propagation pnic devices s for medica
Skills	<ul> <li>Students can calculate the time dependent voltage behavior of an action potential</li> <li>Students can give scenarios for further improvement of low-noise and low-power signal acquisition.</li> <li>Students can develop the block diagrams of prosthetic systems</li> <li>Students can define the building blocks of electronic systems for an articifial eye.</li> </ul>			
Personal Competence				
Social Competence	<ul> <li>Students are trained to solve protogether with experts with differer</li> <li>Students are able to recognize assistance to the right time.</li> <li>Students can document their wor a way that others can be involved</li> </ul>	It professional backgrou their specific limitation k in a clear manner and	nd. ns, so that the d communicate	y can ask fo
Autonomy	<ul> <li>Students are able to realistically actions for improvements when n</li> <li>Students can break down their w work in a realistic way.</li> <li>Students can handle the comple needing support.</li> </ul>	ecessary. ork in appropriate work	packages and	schedule the



	<ul> <li>Students are able experimental work.</li> </ul>	•	manner in all cases and situations of
Workload in Hours	Independent Study Time 1	24, Study Time in Lecture &	56
Credit points	6		
	Compulsory Bonus	Form	Description
Course achievement	Yes None	Subject theoretical practical work	and
	No None	Excercises	
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	Biomedical Engineering: S Compulsory Biomedical Engineering: S Biomedical Engineering: S Biomedical Engineering: S Compulsory Microelectronics and Micr Compulsory Theoretical Mechanical E Compulsory	Specialisation Artificial Organ pecialisation Implants and pecialisation Medical Tech Specialisation Managemen osystems: Specialisation ngineering: Specialisation	ology: Elective Compulsory ans and Regenerative Medicine: Elective Endoprostheses: Elective Compulsory mology and Control Theory: Compulsory nt and Business Administration: Elective Microelectronics Complements: Elective Bio- and Medical Technology: Elective plementary Course: Elective Compulsory

Course L0696: Electro	nic Circuits for Medical Applications		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>		
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
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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



Courses				
Title Continuum Moobonios (I. 1	522)	<b>Typ</b> Lecture	Hrs/wk 2	CP 2
Continuum Mechanics (L1 Continuum Mechanics Ex	-	Recitation Section (small)		3 3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain			
Educational Objectives	After taking part successfully, students have re	eached the following lea	rning result	is
Professional Competence				
Knowledge	The students can explain the fundamental comaterials.	oncepts to calculate the	mechanica	al behavior
Skills	The students can set up balance laws and aspects, both in applied contexts as in resear		nation theo	ry to speci
Personal Competence				
Social Competence	The students are able to develop solutions, to develop ideas further.	present them to special	ists in writte	en form and
Autonomy	The students are able to assess their independently and on their own identify a mechanics and acquire the knowledge require	and solve problems in		-
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: E Mechanical Engineering and Management: S Mechatronics: Technical Complementary Cou Biomedical Engineering: Specialisation Artific Compulsory Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Mer Compulsory Biomedical Engineering: Specialisation Man Compulsory	Specialisation Materials: Urse: Elective Compulson Cial Organs and Regene ants and Endoprostheses dical Technology and (	ry rrative Medi s: Elective C Control The	cine: Electiv Compulsory eory: Electiv



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section	n (small) 2	3
	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuer Mechanics II and Continuum Mechanics strain, free-body principle, linear and no	cs (forces and momer	nts, stress, linear	
Educational Objectives	After taking part successfully, students h	ave reached the follow	ving learning resu	Its
Professional Competence				
Knowledge	The students can explain the fundamen	tals of multidimensiona	al consitutive mate	erial laws
Skills	The students can implement their own students can apply their knowledge to v corresponding material models.			•
Personal				
Competence				
Social Competence	The students are able to develop solu ideas further.	itions, to present then	n to specialists a	nd to develop
Autonomy	The students are able to assess independently and on their own identify and acquire the knowledge required to t	and solve problems in		-
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Computational Science and Enginee Compulsory Materials Science: Specialisation Mode Mechanical Engineering and Managem Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Product Development, Materials and Pro Theoretical Mechanical Engineering: Specialisation	ling: Elective Compuls ent: Specialisation Ma Artificial Organs and F Implants and Endopro n Medical Technology n Management and Bu poduction: Core qualific	ory terials: Elective Co Regenerative Mec ostheses: Elective y and Control Th usiness Administr ation: Elective Co	ompulsory dicine: Elective Compulsory neory: Elective ration: Elective mpulsory

Course L1535: Materia	al Modeling
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: Materia	al Modeling
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: A	Advance	ed Functio	onal Mater	rials				
Courses								
<b>Title</b> Advanced Functional Mat	erials (L162	5)			<b>yp</b> eminar	<b>Hrs</b> / 2	wk	<b>CP</b> 6
Module Responsible	Prof. Patr	ick Huber						
Admission Requirements	None							
Recommended Previous Knowledge		Basic knowledge in Materials Science, e.g. Materials Science I/II						
Educational Objectives	Atter takir	ng part succes	sfully, studen	nts have read	ched the follow	wing learning	resul	ts
Professional								
Competence	1	opto will be -		in the second	artico ofl-			' المانين ممر
Knowledge	The students will be able to explain the properties of advanced materials along with the applications in technology, in particular metallic, ceramic, polymeric, semiconductor, moder composite materials (biomaterials) and nanomaterials.							
Skills	The students will be able to select material configurations according to the technical need and, if necessary, to design new materials considering architectural principles from the micro to the macroscale. The students will also gain an overview on modern materials science which enables them to select optimum materials combinations depending on the technica applications.			om the micro rials science				
Personal Competence								
Social Competence	The stude	ents are able to	o present solu	utions to spe	cialists and to	o develop ide	as fur	ther.
	The stude	ents are able to	n					
Autonomy	• as	sess their own	n strengths ar					
Workload in Hours	Independ	ent Study Tim	e 152, Study	Time in Lec	ture 28			
Credit points	6							
Course achievement	None							
Examination	J	ion						
Examination duration and scale	130 min							
Assignment for the Following Curricula	Materials Science: Core qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Biomedical Mechanical Engineering: Technical Complementary Course: Elective Compulsor Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory							

ourse L1625: Advand	ced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>
Literature	Wird in der Veranstaltung bekannt gegeben

Courses							
<b>Title</b> Introduction to Biochemist	try and Molecular Biology (L0386)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3			
Module Responsible	Prof. Hans-Jürgen Kreienkamp						
Admission Requirements	None						
Recommended Previous Knowledge	None						
Educational Objectives	After taking part successfully students	have reached the follow	ing learning resul	ts			
Professional Competence							
Knowledge	<ul> <li>explain now genetic information</li> <li>explain the connection between</li> </ul>						
Skills	<ul> <li>The students can</li> <li>recognize the importance of molecular parameters for the course of a disease;</li> <li>describe selected molecular-diagnostic procedures;</li> <li>explain the relevance of these procedures for some diseases</li> </ul>						
Personal Competence							
Social Competence	The students can participate in discussions in research and medicine on a technical level. The students can develop understanding of topics from the course, using technical literature.						
Autonomy	by themselves.						
Workload in Hours	Independent Study Time 62, Study Tir	ne in Lecture 28					
Credit points	3						
Course achievement							
	Written exam						
Examination duration and scale	60 minutes						
	General Engineering Science (Gerr			n Mechanica			

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

IO I: Implants and Fracture Healing		
aling (L0376) Typ	Hrs/wk CP 2 3	
Prof. Michael Morlock		
None		
It is recommended to participate in "Introduction into An Fracture Healing".	atomie" before attending "Implants ar	
After taking part successfully, students have reached the	e following learning results	
The students can describe the different ways how bones heal, and the requirements for the existence. The students can name different treatments for the spine and hollow bones under give fracture morphologies.		
The students can determine the forces acting withir situations under specific assumptions.	n the human body under quasi-stat	
The students can, in groups, solve basic numerical internal forces.	modeling tasks for the calculation	
The students can, in groups, solve basic numerical internal forces.	modeling tasks for the calculation of	
Independent Study Time 62, Study Time in Lecture 28		
3		
None		
Written exam		
90 min		
Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7	semester): Specialisation Biomedic semester): Specialisation Mechanic semester): Specialisation Biomedic : Compulsory s and Regenerative Medicine: Electiv ndoprostheses: Elective Compulsory nnology and Control Theory: Electiv	
	Aling (L0376) Lecture Prof. Michael Morlock None It is recommended to participate in "Introduction into An Fracture Healing". After taking part successfully, students have reached th The students can describe the different ways how bon existence. The students can name different treatments for the fracture morphologies. The students can determine the forces acting withir situations under specific assumptions. The students can, in groups, solve basic numerical internal forces. The students can, in groups, solve basic numerical internal forces. Independent Study Time 62, Study Time in Lecture 28 3 None Written exam 90 min General Engineering Science (German program, 7 Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Medical Tecl Compulsory	

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Course L0376: Implant	ts and Fracture Healing		
Тур	Lecture		
Hrs/wk	2		
СР			
	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language Cycle			
0,010	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)		
Content	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		
	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		
Literature	Schiebler T.H., Schmidt W.: Anatomie		
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat		
	l		

Module M1334: E	BIO II: Biomaterials		
Courses			
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23		
	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.		
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials		
Personal Competence			
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.		
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
	Written exam		
Examination duration and scale	19() min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	

Lecturer Language	Prof. Michael Morlock EN
Cycle	WiSe
	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
Content	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.
	Hastings C and Dushoung R: Natural and living biometarials, Page Rates: CPC Pross, 1984
	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.
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	[202]

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer,
1996.

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Courses					
Title			Тур	Hrs/wk	СР
Finite Element Methods (L Finite Element Methods (L			Lecture Recitation Section (large)	2	3 3
	Prof. Otto von Estorff			L	0
Admission	J				
Requirements	None				
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics Dynamics) Mathematics I, II, III (in particular differential equations)				
Educational Objectives	Atter taking nart successt	ully, students ha	ve reached the following lea	arning resul	ts
Professional					
Competence	1	n in-depth know	ledge regarding the deriva	tion of the	finite elomo
	method and are able to	•	ew of the theoretical and		
Knowladge	method.				
Knowledge					
Skills	equations.	e corresponding	system matrices, and solvir	ng the resul	ting system
Personal Competence					
Social Competence	Students can work in sma	all groups on spe	cific problems to arrive at jo	oint solution	S.
		to independent	y solve challenging com	outational r	problems au
	develop own finite eleme	•	blems can be identified and	•	
Autonomy	scrutinized.				
· · · · · · · · · · · · · · · · · · ·					
Workload in Hours	Independent Study Time	124, Study Time	in Lecture 56		
Credit points	6				
Course achievement	Compulsory Bonus No 20 %	<b>Form</b> Midterm	Descriptio	on	
Examination	Written exam				
Examination duration and scale	120 min				
and scale	Civil Engineering: Core q Energy Systems: Core qu	ialification: Elect ring: Specialisat	ve Compulsory on Aircraft Systems: Electiv	•	-

	International Management and Engineering: Specialisation II. Mechatronics: Elective
	Compulsory
	International Management and Engineering: Specialisation II. Product Development and
	Production: Elective Compulsory
Assignment for the	Mechatronics: Core qualification: Compulsory
Following Curricula	Biomodical Engineering, Cassialisation Implents and Endeprestheses, Compulsery
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
	Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
	Compulsory
	Product Development, Materials and Production: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Compulsory

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

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

Module	M1342:	Poly	/mers

Courses				
Title Structure and Properties of Processing and design with		<b>Typ</b> Lecture Lecture	Hrs/wk 2 2	<b>CP</b> 3 3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / mate	erial science		
Educational Objectives	I After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin contexts (e.g. sustainability, environmental protection).			
Skills	<ul> <li>Students are capable of</li> <li>using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.</li> <li>selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.</li> </ul>			
Personal Competence				
Social Competence	Students can - arrive at funded work results in l - provide appropriate feedback a			constructively
Autonomy	Students are able to - assess their own strengths and - assess their own state of learn basis. - assess possible consequences	ing in specific terms and to de	efine further work	steps on th
Workload in Hours	Independent Study Time 124, Stu	udy Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
	Materials Science: Specialisation Biomedical Engineering: Special			sory

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective					
	Compulsory					
	Biomedical Engineering: Specialisation Management and Business Administration: Elective					
	Compulsory					
A a a i www.a wt faw.tha	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective					
Assignment for the						
Following Curricula	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 Compulsory					
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory					
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory					

Course L0389: Structu	are and Properties of Polymers
Тур	Lecture
Hrs/wk	2
СР	3
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
Content	<ul> <li>Structure and properties of polymers</li> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology <ul> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> <li>Applications</li> </ul> </li> </ul>
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Proces	sing and design with polymers	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich	
Language	DE/EN	
Cycle	WiSe	
Content	Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Mou 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	

Madula M0622; E	Pagaparativa Madiai	ino					
	Regenerative Medici	ine					
Courses							
<b>Title</b> Regenerative Medicine (L	0347)		<b>Typ</b> Seminar	Hrs/wk 2	<b>СР</b> 3		
	ng - Regenerative Medicine (L	1664)	Seminar	2	3		
Module Responsible							
Admission Requirements	None						
Recommended Previous Knowledge							
Educational Objectives	After taking part successfu	Illy, students have re	eached the following	ng learning resul	ts		
Professional Competence							
Knowledge	of regenerative medicine tissue engineering. They animal and human cells.	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.					
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic udnerlying principles of the discussed topics. After successful completion of the module students are						
Skills	<ul> <li>able to use medical databases for acquirierung and presentation of relevant up-to-date data independently</li> <li>able to present their work results in the form of presentations</li> <li>able to carry out basic cell culture methods and the corresponding analysis independently</li> <li>able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine.</li> </ul>						
Personal							
Competence							
	Students are able to wor	-		ents to solve give	ven tasks and		
Social Competence	discuss their results in the plenary and to defend them. Students are able to reflect their work orally and discuss it with other students and teachers.						
Autonomy	After completion of this mo of approx. 2-4 persons ind				blem in team		
	Independent Study Time 1	24, Study Time in L	ecture 56				
Credit points	6						
Course achievement	Compulsory BonusYes20 %	Form Written elaboration	Ausa	<b>cription</b> arbeitung zu Rir ocol for lecture se			
Examination	Presentation						
Examination duration and scale	Oral presentation + discus	ssion (30 min)					
	I						

Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective	•
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	

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

Course L1664: Lecture	e Tissue Engineering - Regenerative Medicine	
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content	iscussion of current research topics for tissue engineering and regenerative medicine by vited 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	

Module M0548: E	Bioelectromagnetics	: Principles an	d Applications		
Courses					
Title			Тур	Hrs/wk	СР
-	ciples and Applications (L0371) ciples and Applications (L0373)		Lecture Recitation Section (small)	3	5 1
-		)	Recitation Section (Smail)	2	I
-	Prof. Christian Schuster				
Admission Requirements	NONE				
Recommended Previous Knowledge					
Educational Objectives	After taking part successful	lly, students have re	ached the following lea	rning resu	ts
Professional					
Competence					
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.				
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.				
Personal Competence					
Social Competence	Students are able to work present their results effective				ey are able t
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points					
Course achievement	Compulsory Bonus Yes 10 %	<b>Form</b> Presentation	Descriptio	on	

Examination	
Examination duration and scale	45 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

ourse L0371: Bioeleo	tromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	- 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
Content	- 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
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CF (2009)
Literature	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wile (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagne Fields", CRC (2006)

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

Courses					
Title		Тур		Hrs/wk	СР
Case Studies for Regene	rative Medicine and Tissue Engineering (L1963)	Semina	r	3	6
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part euccosefully etudente have	reached	he following	learning resul	ts
Professional Competence					
Knowledge Skills					
Personal Competence					
Social Competence Autonomy					
	Independent Study Time 138, Study Time in	Lecture 4	2		
Credit points					
Course achievement					
Examination	Presentation				
Examination duration and scale	45 min				
Assignment for the Following Curricula	Biomedical Engineering: Specialisation	Artificial	Organs and	d Regenerati	ve Medici

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

Module M0630: R	lobotics and	d Naviga	ation in Medici	ne		
Courses						
Title	- Madiaira (L.0005)	N		Тур	Hrs/wk	СР
Robotics and Navigation in Robotics and Navigation in				Lecture Project Seminar	2 2	3 2
Robotics and Navigation in				Recitation Section (small)	1	1
Module Responsible	Prof. Alexander	Schlaefer				
Admission Requirements	None					
Recommended Previous Knowledge	<ul> <li>principle</li> </ul>		algebra, analysis/ca amming, e.g., in Java kills	-		
Educational Objectives	After taking part	successfu	lly, students have re	eached the following lea	rning resu	lts
Professional Competence						
Knowledge	systems and the	eir compor safety and	nents in detail. Syst	cking systems in clinica tems can be evaluated ts can assess typical sy	with respe	ect to collisi
Skills	The students are able to design and evaluate navigation systems and robotic systems t medical applications.					
Personal Competence	The students (	discuss th	e results of other	groups, provide help	oful feedb	ack and c
Social Competence				groups, provide help		
Autonomy			heir knowledge and opropriate manner.	d document the results	of their w	ork. They c
Workload in Hours	Independent Stu	udy Time 1	10, Study Time in L	ecture 70		
Credit points	6					
Course achievement		onus ) % ) %	<b>Form</b> Written elaboration Presentation	Descriptio	n	
Examination	Written exam					
Examination duration and scale	90 minutes					
	Electrical Engin International Ma Compulsory Mechatronics: S Biomedical Eng Compulsory Biomedical Eng	eering: Sp anagement Specialisati ineering: S ineering: S	ecialisation Medical t and Engineering: S on Intelligent Syster Specialisation Artific Specialisation Implan	Engineering: Elective ( Technology: Elective ( Specialisation II. Electric ms and Robotics: Electiv ial Organs and Regene nts and Endoprostheses lical Technology and (	ompulsory cal Engine ve Compul rative Med s: Elective	, ering: Electi sory licine: Electi Compulsory

Assignment for the	Biomedical Engineering: Specialisation Management and Business Administration: Elective
Following Curricula	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 Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective
	Compulsory
	Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective

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

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

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

## TUHH Hamburg University of Technology

Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical	Technology and Systems (LC	0342)	Lecture	2	3
Introduction into Medical	Technology and Systems (LC	)343)	Project Seminar	2	2
Introduction into Medical	Technology and Systems (L1	876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefe	r			
Admission Requirements	NONE				
	principles of math (algeb	ra, analysis/calculus	)		
Recommended	principles of stochastics				
Previous Knowledge	principles of programmin	ig, 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 technology, including imaging systems computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.				
Skills	The students are able to evaluate systems and medical devices in the context of clinica applications.				
Personal					
Competence					
Competence		problem in medical t	echnology as a project,	and define	tasks that ar
Competence Social Competence	The students describe a	t their knowledge an	nd document the results		
Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect	t their knowledge an appropriate manner.	nd document the results		
Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge an appropriate manner.	nd document the results		
Competence Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge an appropriate manner.	nd document the results	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b>	t their knowledge an appropriate manner. 110, Study Time in L	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b>	t their knowledge an appropriate manner. 110, Study Time in L Form	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 %	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboratior	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboratior	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboration Presentation	ecture 70 Description	of their wo	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation	Description Description	of their we	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y sialisation Computer a	Description Description Description	of their we	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer store qualification: Ele	Description Description Description Description Description Segram, 7 semester): Sp and Software Engineerin Sective Compulsory	of their we	ork. They ca n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering: C General Engineering S	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y cialisation Computer s core qualification: Ele cience (English pro	Description Description Description Description Description Segram, 7 semester): Sp and Software Engineerin Sective Compulsory	of their we	ork. They ca n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y sialisation Computer s ore qualification: Ele cience (English pro y	Description Description Description Description Description Description Description N Description N	of their we	ork. They ca n Biomedica Compulsory n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer st tore qualification: Ele cience (English pro y and Engineering: Ilsory	Description Description Description Description Description N Description N Description N Description N Specialisation II. Math	of their we	n Biomedica Compulsory Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer st tore qualification: Ele cience (English pro y and Engineering: Ilsory	Description Description Description Description Description N Description N Description N Description N Specialisation II. Math	of their we	n Biomedica Compulsory Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: ilsory and Engineering:	Description Description Description Description Description N Description N Description N Description N Specialisation II. Math : Specialisation Comp	of their we	n Biomedica Compulsory Biomedica Engineering
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory Computational Science	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: ilsory and Engineering:	Description Description Description Description Description N Description N Description N Description N Specialisation II. Math : Specialisation Comp	of their we	ork. They ca n Biomedica Compulsory n Biomedica Engineerin nce: Electiv
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y cialisation Computer a core qualification: Election computer a core qualification: Election computer a core qualification: Election computer a core qualification computer a core qualifi	bd document the results ecture 70 Description Description Description Description Description Specialisation Engineerin Specialisation II. Math Specialisation Comp Specialisation Engineering Specialisation Enging Specialisation Engineering S	of their we	n Biomedica Compulsory Biomedica Engineering nce: 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 L0342: Introdu	ction into Medical Technology and Systems	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>imaging systems</li> <li>computer aided surgery</li> <li>medical sensor systems</li> <li>medical information systems</li> <li>regulatory affairs</li> <li>standard in medical technology</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>	
Literature	Wird in der Veranstaltung bekannt gegeben.	

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

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

Courses				
<b>Title</b> Nonlinear Dynamics (L07	02)	<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul><li>Calculus</li><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	develop and research new terms and con-	cepts.		
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and t develop novel methods and procedures.			
Personal Competence				
Social Competence	Students can reach working results also ir	groups.		
Autonomy	Students are able to approach given rese novel research tasks by themselves.	arch tasks individually a	nd to identify	and follow ι
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsor Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective			

Course L0702: Nonline	ourse L0702: Nonlinear Dynamics		
Тур	Integrated Lecture		
Hrs/wk			
СР	6		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Lecturer	Prof. Norbert Hoffmann		
Language	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 Technolog		Lecture Practical Course	4	4
Semiconductor Technolog	•	Practical Course	2	2
	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, m	aterial science and semiconducto	or devices	
Educational Objectives	After taking part successfully, st	udents have reached the followin	ig learning resu	lts
Professional Competence				
	Students are able			
	• to describe and to explain c	urrent fabrication techniques for S	Si and GaAs sub	ostrates,
Knowledge		relevant fabrication processes, p niconductor devices and integrate		nd the impa
	<ul> <li>to present integrated proces</li> </ul>	ss flows.		
	Students are capable			
	• to analyze the impact of pro	cess parameters on the processir	ng results,	
Skills	<ul> <li>to select and to evaluate pro</li> </ul>	ocesses and		
		r the fabrication of semiconductor	devices.	
Personal Competence				
Social Competence	Students are able to prepare a present and discuss the results	and perform their lab experimen in front of audience.	ts in team work	as well as t
Autonomy	None			
	Independent Study Time 96, St	udy Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
<b>Examination duration</b>	30 min			

Course L0722: Semico	onductor Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochratski , Bridgeman and float zone process)</li> <li>Wafer fabrication (process flow, specification, SOI)</li> <li>Fabrication processes</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>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 undercuting, compensation masks and etch stop techniques; dy etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> <li>Process integration (CMOS process, bipolar</li></ul>

	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
Literature	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: Semico	onductor Technology
Тур	Practical Course
Hrs/wk	2
СР	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

Courses					
<b>Title</b> Humanoid Robotics (L066	3)		<b>Typ</b> Seminar	Hrs/wk 2	<b>CP</b> 2
Module Responsible	Patrick	Göttsch			
Admission Requirements					
Recommended Previous Knowledge		Introduction to control Control theory and dea	-		
Educational Objectives	After ta	king part successfully,	students have reached the followi	ng learning resul	lts
Professional Competence					
Knowledge		Students can explain I Students learn to appl	numanoid robots. y basic control concepts for differe	nt tasks in huma	noid robotics.
Skills		specified literature Students generalize d	wledge about selected aspects of eveloped results and present then repare and give a presentation		
Personal Competence					
Social Competence	•	them	of developing solutions in interd vide appropriate feedback and h		•
Autonomy		specific tasks and sele Students familiarize th	vantages and drawbacks of diffe ect the best solution emselves with a scientific field, are students, such that a scientific dise	e able of introduc	e it and follo
Workload in Hours	Indepe	ndent Study Time 32, S	Study Time in Lecture 28		
Credit points	2				
Course achievement					
Examination		itation			
Examination duration and scale	30 min				
Assignment for the Following Curricula	Mecha Biome Compu Biome	tronics: Specialisation dical Engineering: Spe Ilsory dical Engineering: Spe dical Engineering: Spe	Intelligent Systems and Robotics: System Design: Elective Compuls cialisation Artificial Organs and Re cialisation Implants and Endopros ecialisation Medical Technology	ory egenerative Med	licine: Electiv

Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Title Linear and Nonlinear Syst Module Responsible	em Identification (1.0660)	Tun	/ .	
		<b>Typ</b> Lecture	<b>Hrs/wk</b> 2	<b>СР</b> 3
<b>.</b>				
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Classical control (frequency</li> <li>State space methods</li> <li>Discrete-time systems</li> <li>Linear algebra, singular valu</li> <li>Basic knowledge about stoc</li> </ul>	ue decomposition		
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ving learning resu	lts
Professional Competence				
Knowledge	<ul> <li>Students can explain the g application to a variety of line</li> <li>They can explain how multidynamics</li> <li>They can explain how an a neural network models</li> <li>They can explain the idea realisation theory</li> </ul>	ear and nonlinear model st tilayer perceptron network approximate predictive cor	tructures is are used to mo ntrol scheme can	odel nonline be based c
Skills	<ul> <li>Students are capable of an identification of linear and not identification of linear and not.</li> <li>They are capable of implement neural network model</li> <li>They are capable of applyin linear models for dynamic sy.</li> <li>They can do the above usi Identification Toolbox)</li> </ul>	onlinear models for dynami nenting a nonlinear predict g subspace algorithms to th ystems	ic systems tive control schem he experimental id	ne based on dentification
Personal Competence				
Social Competence			-	
Autonomy	Students are able to find required software documentation) and use it		ovidea (lecture no	nes, literatur
Workload in Hours	Independent Study Time 62, Study	Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			

	Mechatronics: Specialisation System Design: Elective Compulsory
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
Following Curricula	Compulsory
i oliowing our lioulu	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses						
<b>Fitle</b> Optimal and Robust Conti	ol (L06	58)	<b>Typ</b> Lecture		<b>Hrs/wk</b> 2	<b>СР</b> 3
Optimal and Robust Conti			Recitation Section			3
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	•	Classical control (frequer State space methods Linear algebra, singular v				
Educational Objectives	After ta	aking part successfully, stu	dents have reached the follo	wing lear	ning resul	ts
Professional Competence						
Knowledge	•	LQ problems. They can explain the c estimation. They can explain how the performance constraints. They can explain how ar an H2 design problem. They can explain how m to robust controller design They can explain how - guarantee stability and per	based on the small gain the erformance for an uncertain p nalysis and synthesis condition	ate feedb re used to be formul esented i neorem - blant.	back and prepreser ated as sp in a way th a robust	optimal sta nt stability a pecial case nat lends its controller c
Skills	•	models. They are capable of repr generalized plant, and of They are capable of tran loops into constraints on sensitivity design. They are capable of con and of designing a mixed They are capable of form inequalities (LMI), and of	designing and tuning LQG or resenting a H2 or H-infinity using standard software tool slating time and frequency of closed-loop sensitivity function structing an LFT uncertainty objective robust controller. nulating analysis and synth using standard LMI-solvers for the above using standard soft	design p s for solv domain s ons, and r model for nesis con or solving	roblem in ing it. pecificatic of carrying or an unco ditions as g them.	the form o ons for cont g out a mixe ertain syste linear mat
Personal Competence						
Social Competence			s on specific problems to arr	-		
Autonomy		-	ed information in sources present to solve given problems.	rovided (	lecture no	tes, literatu

Workload in Hours
Credit points
Course achievement
Examination
Examination duration and scale
Assignment for the Following Curricula

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

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

Courses						
<b>Title</b> Marketing of Innovations (	L2009)			cture	Hrs/wk 4	<b>CP</b> 4
PBL Marketing of Innovati	ons (LO8	362)		oject-/problem-based arning	1	2
Module Responsible	Prof. C	hristian Lüthje				
Admission Requirements	None					
Recommended Previous Knowledge	•	Module International Busin Basic understanding of but theory, project manageme Bachelor-level Marketing Strategies, Basics of Buyin Unerstanding the different Understanding of the impo Good English proficiency;	isiness administ ent, international Knowledge (Ma ng Behavior) ces beweetn B2 ortance of mana	l business) arketing Instruments B and B2C marketir ging innovation in g	s, Market an	nd Competit
Educational Objectives	After ta	king part successfully, stuc	lents have reac	hed the following lea	arning resul	ts
Professional Competence						
Knowledge	<ul> <li>Approaches and tools for ensuring customer-orientation in the development of neuproducts and innovative services</li> <li>Marketing mix elements that take into consideration the specific requirements and challenges of innovative products and services</li> <li>Pricing methods for new products and services</li> <li>The organization of complex sales forces and personal selling</li> <li>Communication concepts and instruments for new products and services</li> </ul>					
Skills	• • •	on the acquired knowledge Design and to evaluate de Analyze markets by apply Conduct forecasts and de Translate customer need successfully apply advar development Use adequate methods to Choose suitable pricing st Make strategic sales de channels) Apply methods of sales for	ecisions regardin ing market and t velop compellin ds into concep nced methods foster efficient of rategies and co cisions for pro	ng marketing and in technology portfolio g scenarios as a ba ots, prototypes and for customer-orient diffusion of innovativ mmunication activiti ducts and services	s sis for strate l marketab ted product re products ies for innov s (i.e. selec	egic plannin le offers au t and servi and services vations

Social Competence	<ul> <li>have fruitful discussions and exchange arguments</li> <li>develop original results in a group</li> <li>present results in a clear and concise way</li> <li>carry out respectful team work</li> </ul>					
Autonomy	<ul> <li>The students will be able to</li> <li>Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields.</li> <li>Consider proposed business actions in the field of marketing and reflect on them.</li> </ul>					
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70					
Credit points	6					
Course achievement	None					
Examination	Subject theoretical and practical work					
Examination duration and scale	Written elaboration, excercises, presentation, oral participation					
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective					

TUHH

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

Course L0862: PBL Ma	arketing of Innovations	
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Christian Lüthje	
Language	EN	
Cycle	SoSe	
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing is students' practical skills in (1) forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation, managing the market mix). The students will be prompted to use the knowledge gathered in the lecture of t module and will be invited to (1) Conduct a scenario analysis for an innovative prod category and (2) Engage in decision making wtihin a market simulation game.	
Literature		

Courses					
Title			Тур	Hrs/wk	СР
Bioprocess Engineering -			Lecture	2	3
Bioprocess Engineering- I		- (1.00.40)	Recitation Section (large) Practical Course		1
	Fundamental Practical Cours	e (LU843)	Practical Course	2	2
Module Responsible Admission					
Requirements	None				
Recommended Previous Knowledge	none, module "organic ch	emistry", module	"fundamentals for process	engineerir	ıg"
Educational Objectives	After taking part successfu	ully, students have	e reached the following lea	rning resul	lts
Professional Competence					
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.				
Skills	<ul> <li>After successful completion of this module, students should be able to</li> <li>describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters</li> <li>predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process</li> <li>analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations</li> <li>distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply then to current biotechnical problem</li> <li>propose solutions to complicated biotechnological problems and to deduce the corresponding models</li> <li>to explore new knowledge resources and to apply the newly gained contents</li> <li>identify scientific problems with concrete industrial use and to formulate solutions.</li> <li>to document and discuss their procedures as well as results in a scientific manner</li> </ul>				
Personal Competence	After completion of this n	nodule participant	s should be able to deba	te technica	I questions
Social Competence	After completion of this module participants should be able to debate technical questions ir small teams to enhance the ability to take position to their own opinions and increase thei capacity for teamwork in engineering and scientific environments.				
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.				
Workload in Hours	Independent Study Time	96, Study Time in	Lecture 84		
Credit points	6				

	practical work				
	Written exam				
Examination duration and scale	90 min				
-	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, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: 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 Process Engineering: Core qualification: Compulsory				

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

Course L0842: Bioprocess Engineering- Fundamentals				
Тур	Recitation Section (large)			
Hrs/wk	2			
СР				
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	<ol> <li>Introduction (Prof. Liese, Prof. Zeng)</li> <li>Enzymatic kinetics (Prof. Liese)</li> <li>Stoichiometry I + II (Prof. Liese)</li> <li>Microbial Kinetics I+II (Prof. Zeng)</li> <li>Rheology (Prof. Liese)</li> <li>Mass transfer in bioprocess (Prof. Zeng)</li> <li>Continuous culture (Chemostat) (Prof. Zeng)</li> <li>Sterilisation (Prof. Zeng)</li> <li>Downstream processing (Prof. Liese)</li> <li>Repetition (Reserve) (Prof. Liese, Prof. Zeng)</li> </ol>			
Literatura	siehe Vorlesung			
Literature	siene vonesung			

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

Module M1143: N	lechanical Design Me	thodology		
Courses				
<b>Title</b> Mechanical Design Metho Mechanical Design Metho		<b>Typ</b> Lecture Recitation Section (se	<b>Hrs/wk</b> 3 mall) 1	<b>CP</b> 4 2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	, students have reached the following	g learning resu	lts
Professional Competence <i>Knowledge</i>	Science-based working on pi design techniques	roduct design considering targeted a	application of s	pecific produc
Skills	Creative handling of proces product design problems / theoretical aspects.	eses used for scientific preparation Application of various product d	and formulatio lesign techniq	on of comple ues following
Personal Competence				
Social Competence				
Autonomy Workload in Hours	Independent Study Time 124	Study Time in Lecture 56		
Credit points		, olddy fille in Leolare 50		
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula				

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

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

IED I: Introduction to Anotomy		
L0384) Typ Lecture	<b>Hrs/wk</b> 2	<b>СР</b> 3
Prof. Udo Schumacher		
None		
None		
After taking part successfully, students have reached the following lea	arning resul	ts
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.		
The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explain the relevance of structures and their functions in the context of widespread diseases.		
The students can participate in current discussions in biomedical research and medicine on a professional level.		
The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the relevant knowledge themselves.		
Independent Study Time 62, Study Time in Lecture 28		
3		
None		
Written exam		
90 minutes		
General Engineering Science (German program, 7 semester): Specialisation Biomedica Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica 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		
	Date         Lecture           Prof. Udo Schumacher         None           None         None           After taking part successfully, students have reached the following le         Image: Computer Science Science           The students can describe basal structures and functions of it musculoskeletal system.         Image: Computer Science           The students can describe the basic macroscopy and microscopy of         Image: Computer Science           The students can recognize the relationship between given a development of some common diseases; they can explain the relist functions in the context of widespread diseases.           The students can participate in current discussions in biomedical resprofessional level.           The students are able to access anatomical knowledge by thems conversations on the topic and acquire the relevant knowledge them Midependent Study Time 62, Study Time in Lecture 28           3           None           Written exam           90 minutes           General Engineering Science (German program, 7 semester): S Engineering; Compulsory           General Engineering Science (English program, 7 semester): S Engineering, Focus Biomechanics: Compulsory           General Engineering Science (English program, 7 semester): S Engineering; Cous Biomechanics: Compulsory           General Engineering Science (English program, 7 semester): S Engineering; Cous Biomechanics: Compulsory           Benderical Engineering: Specialisation Medical Technology: Elective E General Enginee	Typ         Hrs/wk           0384)         Lecture         2           Prof. Udo Schumacher

Course L0384: Introduction to Anatomy			
Тур	Lecture		
Hrs/wk	2		
СР	3		
	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Tobias Lange		
Language			
Cycle			
	General Anatomy1 st week:The Eucaryote Cell2 <sup>nd</sup> week:The Tissues3 <sup>rd</sup> week:Cell Cycle, Basics in Development4 <sup>th</sup> week:Musculoskeletal System5 <sup>th</sup> week:Cardiovascular System		
Content	6th week:Respiratory System7th week:Genito-urinary System8th week:Immune system9th week:Digestive System I10th week:Digestive System II11th week:Endocrine System12th week:Nervous System13th week:Exam		
Literature	Adolf Faller/Michael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verla Stuttgart, 2012	a	

Courses				
F <b>itle</b> ntroduction to Radiology a	and Radiation Therapy (L0383)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ving learning resu	lts
Professional Competence				
	<b>Therapy</b> The students can distinguish differe in radiation therapy.	nt types of currently used e	equipment with res	spect to its u
	The students can explain treatme contexts (e.g. surgery, internal medi	•	ion therapy in in	terdisciplina
	The students can describe the pa follow-up care.	tients' passage from the	ir initial admittan	ce through
	Diagnostics			
Knowledge	The students can illustrate the tech angiography and mammography, as			
	The students can explain the diagn well as the technical basis for those	•	c use of imaging t	echniques,
	The students can choose the right tr and needs.	eatment method dependir	ng on the patient's	clinical histo
	The student can explain the influence	ce of technical errors on th	e imaging techniqi	ues.
	The student can draw the right con error protocol.	clusions based on the im	ages' diagnostic f	indings or t
	<b>Therapy</b> The students can distinguish curative that conclusion.	ve and palliative situations	and motivate why	r they came
	The students can develop adequate aspects.	e therapy concepts and re	late it to the radia	tion biologio
	The students can use the therapeuti	c principle (effects vs adve	erse effects)	
Skills	The students can distinguish differe on the situation (location of the t (irradiation planning).			•
	The student can assess what an inc up treatment, sports, social help gro			
	Diagnostics			
		s for repairs of imaging in		

	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.		
Personal Competence			
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.		
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine. The students are able to access anatomical knowledge by themselves, can participate competently 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	3		
Course achievement	None		
	Written exam		
Examination duration and scale	90 minutes		
-	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, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0383: Introduction to Radiology and Radiation Therapy		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring	
Language	DE	
Cycle	SoSe	
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments	

Literature	<ul> <li>"Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999</li> <li>"Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –</li> <li>4. Auflage - Verlag Urban &amp; Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1</li> <li>"Strahlentherapie und Onkologie für MTA-R" von R. Sauer –</li> <li>5. Auflage 2003 - Verlag Urban &amp; Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6</li> <li>"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus</li> <li>8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8</li> <li>"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</li> <li>"Praxismanual Strahlentherapie" von Stöver / Feyer –</li> <li>1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000</li> </ul>

Courses				
Fitle ntroduction to Physiology	(L0385)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students hav	ve reached the follow	ving learning resul	ts
Professional Competence	The students can			
Knowledge	<ul> <li>describe the basics of the energy metabolism;</li> </ul>			
Skills	The students can describe the effects of basic bodily functions (sensory, transmission ar processing of information, development of forces and vital functions) and relate them to simil technical systems.			
Personal Competence				
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical a metrological.			
Autonomy	The students can derive answers to questions arising in the course and other physiologic areas, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time in	1 Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following Curricula	General Engineering Science (German Engineering: Compulsory General Engineering Science (German Engineering, Focus Biomechanics: Compu Electrical Engineering: Specialisation Med General Engineering Science (English Engineering, Focus Biomechanics: Compu General Engineering Science (English Engineering: Compulsory Mechanical Engineering: Specialisation B Biomedical Engineering: Specialisation Compulsory	program, 7 semest ulsory dical Technology: Ele program, 7 semest ulsory program, 7 semest iomechanics: Compu	er): Specialisatio ective Compulsory er): Specialisation ter): Specialisation ulsory	n Mechanio n Mechanio n Biomedio

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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



Module M1332: E	BIO I: Experimental Methods	in Biomechanics		
Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in I	Biomechanics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	"Experimentalla Mathadam"	n "Implantate und Fra	kturheilung" bef	ore attendin
Educational Objectives	Atter taking part successfully students	have reached the follow	ing learning resu	lts
Professional Competence				
Knowledge	The students can describe the different existence. The students can name different treat fracture morphologies. The students can describe different m choose the adequate technique for a g	atments for the spine a easurement techniques	nd hollow bones	s under give
Skills	The students can describe the basic biomechanics.	handling of several exp	perimental techn	iques used i
Personal Competence				
Social Competence	The students can, in groups, solve bas	sic experimental tasks.		
Autonomy	The students can, in groups, solve bas	sic experimental tasks.		
Workload in Hours	Independent Study Time 62, Study Tim	ne in Lecture 28		
Credit points				
Course achievement				
Examination Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (Germ Engineering, Focus Biomechanics: Co General Engineering Science (Germ Engineering: Compulsory General Engineering Science (Engli Engineering, Focus Biomechanics: Co General Engineering Science (Engl Engineering: Compulsory	ompulsory nan program, 7 semest ish program, 7 semest ompulsory ish program, 7 semest on Biomechanics: Compu on Artificial Organs and R n Implants and Endopros on Medical Technology on Management and Bu	er): Specialisatio er): Specialisatio er): Specialisatio er): Specialisatio egenerative Med stheses: Elective and Control Th siness Administra	n Biomedica n Mechanica n Biomedica licine: Electiv Compulsory eory: Electiv ation: Electiv

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

Module M1335: B	BIO II: Artificial Joint Re	eplacement		
Courses				
<b>Title</b> Artificial Joint Replacemer	nt (L1306)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic	c and surgical techniques is recor	mmended.	
Educational Objectives	After taking part successfully, s	students have reached the followi	ng learning resu	lts
Professional Competence				
Knowledge	The students can name the dif	fferent kinds of artificial limbs.		
Skills	The students can explain endoprotheses.	the advantages and disadva	ntages of differ	ent kinds of
Personal Competence				
Social Competence		uss issues related to endoprothe	ese with student i	mates and the
Autonomy	The students are able to acqui with respect to its credibility.	ire information on their own. They	r can also judge t	he information
Workload in Hours	Independent Study Time 62, S	Study Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Biotechnology: Elective Comp Materials Science: Specialisat Biomedical Engineering: Spec Compulsory Biomedical Engineering: Spec Biomedical Engineering: Spec Compulsory Biomedical Engineering: Spec Compulsory Orientierungsstudium: Core que Theoretical Mechanical Engin	nd Engineering: Specialisation oulsory tion Nano and Hybrid Materials: E cialisation Artificial Organs and R cialisation Implants and Endopros ecialisation Medical Technology cialisation Management and Bus ualification: Elective Compulsory eering: Technical Complementary neering: Specialisation Bio- and	Elective Compulse egenerative Med stheses: Compuls and Control Th siness Administr y Course: Electiv	ory licine: Elective cory eory: Elective ation: Elective e Compulsory

Course L1306: Artificia	al Joint Replacement		
Тур	Lecture		
Hrs/wk	2		
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language			
Cycle			
	Inhalt (deutsch)		
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker- satzes)		
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)		
	<ol> <li>DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)</li> </ol>		
Content	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)		
	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		
Literature	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		

Module M0845: F	eedback Control in Medi	cal Technology				
Courses						
Title Feedback Control in Medi	cal Technology (L0664)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3		
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	Basics in Control, Basics in Physic	blogy				
Educational Objectives	After taking part successfully, stud	ents have reached the followi	ng learning resul	ts		
Professional Competence						
	The lecture will introduce into the point of view. Fundamentals in hu in control theory.	ıman physiology will be simila	arly introduced li	ke knowledge		
Knowledge	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 for anesthesia control.					
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.					
Skills	Application of modeling, identifica	tion, control technology in the	field of medical t	echnology.		
Personal						
Competence	Studente con develop colutione te	specific problems in small ar	ouns and present	t their results		
Social Competence	Sudents can develop solutions to	specific problems in small gro	Sups and present			
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.					
Workload in Hours	Independent Study Time 62, Study	/ Time in Lecture 28				
Credit points	3					
Course achievement						
Examination						
Examination duration and scale	20 min					
Assignment for the Following Curricula	Electrical Engineering: Specialisa Electrical Engineering: Specialis Compulsory Biomedical Engineering: Specialis Biomedical Engineering: Specialis Compulsory Biomedical Engineering: Specialis Compulsory	ation Control and Power S sation Implants and Endopros sation Artificial Organs and Re	ystems Enginee theses: Elective ( egenerative Med	ring: Elective Compulsory icine: Elective		
	Biomedical Engineering: Specialis	sation Medical Technology an	d Control Theory	: Compulsor		

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

# Module M0832: Advanced Topics in Control

Title		Тур	Hrs/wk	СР
Advanced Topics in Contr	ol (L0661)	Lecture	2	3
Advanced Topics in Contr	rol (L0662)	Recitation Section (s	mall) 2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sens	sitivity design, linear matrix in	equalities	
Educational Objectives	After taking part successfully, studen	ts have reached the following	learning resu	lts
Professional Competence				
	<ul> <li>Students can explain the scheduling approach</li> <li>They can explain the repressive systems</li> <li>They can explain how stabil formulated as LMI conditions</li> <li>They can explain how grid synthesis problems for LPV s</li> <li>They are familiar with polytop the basic synthesis technique</li> </ul>	sentation of nonlinear system lity and performance condition dding techniques can be us systems pic and LFT representations	ns in the form ons for LPV sy sed to solve of LPV system	of quasi-Lf estems can l analysis a s and some
Knowledge	<ul> <li>Students can explain how communication topology of m</li> <li>They can explain the converg</li> <li>They can explain analysis involving either LTI or LPV age</li> </ul>	nultiagent systems gence properties of first order and synthesis conditions	<sup>r</sup> consensus pr	otocols
	<ul> <li>Students can explain the starsystems that are discretized a</li> <li>They can explain (in outlindistributed systems and the a</li> </ul>	according to an actuator/sens ne) the extension of the bo	or array unded real le	mma to su
	<ul> <li>Students are capable of con mixed-sensitivity design of polytopic, LFT or general LPV</li> <li>They are able to use standar tasks</li> </ul>	gain-scheduled controllers	; they can o	lo this usi
Skills	<ul> <li>Students are able to design either LTI or LPV dynamics, u</li> </ul>		ers for groups	of agents w
	<ul> <li>Students are able to design of using the Matlab MD-toolbox</li> </ul>		ially interconne	ected system

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Attificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Attificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0661: Advance	ed Topics in Control		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling         <ul> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> </ul> </li> <li>Control of Multi-Agent Systems         <ul> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> </ul> </li> <li>Control of Spatially Interconnected Systems         <ul> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul> </li> </ul>		
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>		

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

# Specialization Management and Business Administration

Module M0623: Ir	ntelligent Systems i	n Medicine			
Courses					
<b>Title</b> Intelligent Systems in Mec Intelligent Systems in Mec Intelligent Systems in Mec	dicine (L0334)		<b>Typ</b> Lecture Project Seminar Recitation Section (small)	<b>Hrs/wk</b> 2 2 1	<b>CP</b> 3 2 1
	Prof. Alexander Schlaefer		, , , , , , , , , , , , , , , , , , ,		
Admission Requirements	Nono				
Recommended Previous Knowledge	<ul> <li>principles of stochastic</li> </ul>	amming, Java/C++ a			
Educational Objectives	After taking part successfu	lly, students have re	eached the following lea	Irning resul	ts
Professional Competence					
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
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 th incoorporate feedback into		groups, provide hel	pful feedb	ack and can
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Time 1	10, Study Time in L	ecture 70		
Credit points	6				
Course achievement	Compulsory BonusYes10 %Yes10 %	Form Written elaboration Presentation	Descriptio	on	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Specia Electrical Engineering: Sp Computational Science an Elective Compulsory	ecialisation Medical	Technology: Elective C	Compulsory	

	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0331: Intellige	ent Systems in Medicine
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>
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	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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

### TUHH

# Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Courses				
Title		Тур	Hrs/wk	СР
	ents and Cognitive Robotics (L0341) ents and Cognitive Robotics (L0512)	Lecture Recitation Section (small)	2	4 2
		Recitation Section (smail)	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students have	reached the following lea	rning resu	lts
Professional				
Competence				
Knowledge	and give details about agent design (goal main features of environments. The notion of in terms of decision problems and algorith uncertainty in real-world scenarios, student employed as a knowledge representation settings. In addition, students can defin sequential settings, with and with complet context, students can describe techniques problems, and they can recall techniques for identify techniques for simultaneous local techniques for achieving desired states. S decision making in a multi-agent setting in functions, voting protocol, and mechanism of Students can select an appropriate age	of adversarial agent cooperations for solving these pro- tess can summarize how Bar and reasoning formalism the decision making pro- te access to the state of for solving (partially observed the measuring the value of in- ization and mapping, and Students can explain coor- term of different types of design techniques.	eration can oblems. Fo ayesian ne n in static cedures ir the enviro rvable) Ma nformation d can exp ordination equilibria,	be discussed r dealing with tworks can be and dynamic n simple and nment. In this arkov decision . Students can blain planning problems and social choice
Skills	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different voting protocols and compare and explain the results.			
Personal Competence				
Social Competence	Students are able to discuss their solution English	ns to problems with other	s. They co	mmunicate in
Autonomy	Students are able of checking their underst concrete problems	anding of complex conce	pts by solv	ing varaints of
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points				
Course achievement				
Examination	Written exam			
Examination duration	90 minutes			
-				

and scale	
-	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: 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 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

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

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

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

Courses			
Title	Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

Course L1663: Nature's Hierarchical Materials			
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration			
and scale	Prof. Gerold Schneider		
Language			
Cycle			
	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
<b>Examination Form</b>	Mündliche Prüfung
xamination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
	This course is intended as an introduction to the topics of wave propagation, guiding, sendin and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for enginee that face the technical challenge of transmitting high frequency / high bandwidth data in e medical, automotive, or avionic applications. Both circuit and field concepts of wav propagation and Electromagnetic Compatibility will be introduced and discussed. Topics:
Content	<ul> <li>Fundamental properties and phenomena of electrical circuits</li> <li>Steady-state sinusoidal analysis of electrical circuits</li> <li>Fundamental properties and phenomena of electromagnetic fields and waves</li> <li>Steady-state sinusoidal description of electromagnetic fields and waves</li> <li>Useful microwave network parameters</li> <li>Transmission lines and basic results from transmission line theory</li> <li>Plane wave propagation, superposition, reflection and refraction</li> <li>General theory of waveguides</li> <li>Most important types of waveguides and their properties</li> <li>Radiation and basic antenna parameters</li> <li>Numerical techniques and CAD tools for waveguide and antenna design</li> <li>Fundamentals of Electromagnetic Compatibility</li> <li>Coupling mechanisms and countermeasures</li> <li>Shielding, grounding, filtering</li> <li>Standards and regulations</li> <li>EMC measurement techniques</li> </ul>
Literature	<ul> <li>Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> </ul>

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

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

Course L1580: Experimental Methods for the Characterization of Materials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 min	
Lecturer	Prof. Patrick Huber	
Language	DE	
Cycle	SoSe	
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>	
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: Numer	ical Methods in Biomechanics	
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form		
Examination duration and scale	90 Minuten	
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	<ul> <li>Vorkenntnisse aus "Diskretisierungsmethoden der Mechanik" sind empfohlen</li> <li>Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt.</li> <li>Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten</li> <li>Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden</li> <li>Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt.</li> <li>Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.</li> </ul>	
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009	

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

Course L1130: Six Sig	ma	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and scale	90 Minuten	
Lecturer	Prof. Claus Emmelmann	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>	
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 M	echanics II		
Тур	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration			
and scale			
	Prof. Michael Schlüter		
Language			
Cycle	WiSe		
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>		
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>		

Course L1820: System	n Simulation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and scale	'30 min	
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>	
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>	

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

Course L0379: Ceram	ics Technology	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62	, Study Time in Lecture 28
Examination Form		
Examination duration and scale		
Lecturer	Dr. Rolf Janßen	
Language		
Cycle	WiSe	
	Introduction to ceramic processing with emphasis on advanced structural ceramic course focus predominatly on powder-based processing, e.g. "powder-metau techniques and sintering (soild state and liquid phase). Also, some aspects of gla cement science as well as new developments in powderless forming techniques of ce and ceramic composites will be addressed Examples will be discussed in order engineering students an understanding of technology development and specific appl of ceramic components.	
	Content:	1. Introduction
	Inhalt:	2. Raw materials
Content		3. Powder fabrication
		4. Powder processing
		5. Shape-forming processes
		6. Densification, sintering
		7. Glass and Cement technology
		8. Ceramic-metal joining techniques
	W.D. Kingery, "Introduction t	to Ceramics", John Wiley & Sons, New York, 1975
Literature	ASM Engineering Materials	Handbook Vol.4 "Ceramics and Glasses", 1991
	D.W. Richerson, "Modern C	eramic 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	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	I BIOMAGICAL ENGINAARING, SPACIAIISATION MAGICAL LACHNOLOGY AND L'ONTROL LNAORY. EIACTIVA

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

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

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

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

Course L1580: Experimental Methods for the Characterization of Materials			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form			
Examination duration and scale	90 min		
Lecturer	Prof. Patrick Huber		
Language	DE		
Cycle	SoSe		
Content	<ul> <li>Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)</li> <li>Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)</li> <li>Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)</li> </ul>		
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			
СР			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form			
Examination duration and scale	90 Minuten		
Lecturer	Prof. Michael Morlock		
Language	DE/EN		
Cycle	SoSe		
Content	<ul> <li>Vorkenntnisse aus "Diskretisierungsmethoden der Mechanik" sind empfohlen</li> <li>Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt.</li> <li>Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten</li> <li>Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden</li> <li>Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt.</li> <li>Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.</li> </ul>		
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., Hofmanr Verlag, Schorndorf, 148-69, 2009		

Course L1890: Seminar Biomedical Engineering			
Тур	Seminar		
Hrs/wk	2		
СР			
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		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale			
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>		
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 M	e L0001: Fluid Mechanics II		
Тур	Lecture		
Hrs/wk			
СР			
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale			
	Prof. Michael Schlüter		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>		
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: München, Pearson Studium, 2007</li> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>		

Course L1820: System Simulation			
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale	30 min		
Lecturer	Dr. Stefan Wischhusen		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>		
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.3", Linköping Sweden, 2012</li> <li>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", a Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3 Wiley-IEEE Press, New York, 2015.</li> <li>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical System with Modelica", Wiley, New York, 2011.</li> </ul>		

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

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

Module M0746: N					
Courses					
F <b>itle</b> Aicrosystem Engineering	(L0680)		<b>Typ</b> Lecture	<b>Hrs/wk</b> 2	<b>CP</b> 4
Aicrosystem Engineering	(L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	I None				
Recommended Previous Knowledge	Bacic cources in physics	, mathematics and e	electric engineering		
Educational Objectives	After taking part success	fully, students have	reached the following lea	arning resul	ts
Professional Competence					
-	The students know abou their applications in sens		t technologies and mate	rials of ME	MS as well
Skills	Students are able to ana to evaluate the potential		e functional behaviour o	f MEMS coi	mponents a
Personal					
Competence					
	Students are able to sol	ve specific problem	ns alone or in a group a	nd to prese	ent the resu
Competence Social Competence	Students are able to sol	uire particular know	ledge using specialized		
Competence Social Competence Autonomy	Students are able to sol accordingly. Students are able to acq	uire particular know edge with other field	ledge using specialized l		
Competence Social Competence Autonomy	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time	uire particular know edge with other field	ledge using specialized l		
Competence Social Competence Autonomy Workload in Hours	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time 6 Compulsory Bonus	uire particular know edge with other fielc	ledge using specialized l	literature a	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time 6 Compulsory Bonus	uire particular know edge with other field 124, Study Time in <b>Form</b>	ledge using specialized l ds. Lecture 56	literature a	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time 6 Compulsory Bonus No 10 % Written exam	uire particular know edge with other field 124, Study Time in <b>Form</b> Presentation	ledge using specialized l ds. Lecture 56 <b>Descriptic</b>	literature a	



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

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

Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	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	

Module M0751: V	ibration Theory			
Courses				
<b>Title</b> Vibration Theory (L0701)	TypHrs/wkCPIntegrated Lecture46			
	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Linear Algebra			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them furth			
Skills	Students are able to denote methods of Vibration Theory and develop them further.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vibration Theory.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination				
Examination duration and scale	2 Hours			
-	Energy Systems: Core qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsor Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory Naval Architecture and Ocean Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

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

## TUHH Hamburg University of Technology

Courses				
<b>Fitle</b> <i>A</i> iaraayatama Taabaalaay	(10724)	<b>Typ</b> Lecture	Hrs/wk 2	CP 4
Aicrosystems Technology		Project-/problem-bas	ed –	4
Aicrosystems Technology	y (L0725)	Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, mechani	cs and semiconductor techr	ology	
Educational Objectives	After taking part successfully, students	have reached the following	learning resu	Its
Professional				
Competence	Studente ere chie			
	Students are able			
	<ul> <li>to present and to explain current f methods for the fabrication of micros thereof in more complex systems</li> </ul>			•
Knowledge	• to explain in details operation princ	ciples of microsensors and r	nicroactuators	and
	to discuss the potential and limitati	on of microsystems in appli	cation.	
Skills	<ul> <li>Students are capable</li> <li>to analyze the feasibility of microsy</li> <li>to develop process flows for the fal</li> <li>to apply them.</li> </ul>		and	
Personal				
Competence				
	Students are able to prepare and pe present and discuss the results in fron		in team work	as well as t
Autonomy	None			
Workload in Hours	Independent Study Time 124, Study T	ime in Lecture 56		
Credit points	6			
		Descr		



Course achievement	Yes None	Subject theoretical practical work	and durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebniise ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination			
Examination duration and scale	30 min		
Assignment for the Following Curricula	Elective Compulsory Electrical Engineering: S Computational Science Elective Compulsory International Manager Compulsory Biomedical Engineering Biomedical Engineering Compulsory Biomedical Engineering Compulsory Biomedical Engineering Compulsory	Specialisation Medical Techn and Engineering: Specialis ment and Engineering: S g: Specialisation Artificial Org g: Specialisation Implants and g: Specialisation Medical T	tronics and Microsystems Technology: nology: Elective Compulsory ation Systems Engineering and Robotics: pecialisation II. Mechatronics: Elective gans and Regenerative Medicine: Elective d Endoprostheses: Elective Compulsory Technology and Control Theory: Elective ent and Business Administration: Elective pon: Elective Compulsory

Course L0724: Microsystems Technology		
Тур	Lecture	
Hrs/wk	2	
СР	4	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
Lecturer	Prof. Hoc Khiem Trieu	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>Introduction (historical view, scientific and economic relevance, scaling laws)</li> <li>Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive; angular rate sensor: operating principle and fabrication process)</li> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR,</li> </ul>	

	<ul> <li>fluxgate magnetometer)</li> <li>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)</li> <li>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)</li> <li>MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration)</li> <li>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)</li> <li>System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>
	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
Literature	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

Courses					
Title			Тур	Hrs/wk	СР
Finite Element Methods (L Finite Element Methods (L			Lecture Recitation Section (large)	2	3 3
Module Responsible	·		Recitation Section (large)	۷	5
Admission					
Requirements					
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics Dynamics) Mathematics I, II, III (in particular differential equations)				
Educational Objectives	After taking part successfu	Ily, students have	reached the following lea	rning resul	ts
Professional					
Competence	The students second	in death lineart	as reaction the dealers	ion of 4	finito class
	The students possess an method and are able to	•			
	method.				
Knowledge					
Skills	elements, assembling the equations.			9 110 10001	
Personal Competence					
Social Competence	Students can work in smal	ll groups on specif	c problems to arrive at joi	int solution	5.
	The students are able t develop own finite eleme				
Autonomy	scrutinized.				
Natonomy					
Workload in Hours	Independent Study Time 1	24, Study Time in	Lecture 56		
Credit points	6				
Course achievement	Compulsory BonusNo20 %	<b>Form</b> Midterm	Descriptio	n	
Examination	Written exam				
Examination duration and scale	120 min				
	Civil Engineering: Core qu Energy Systems: Core qua Aircraft Systems Engineer	alification: Elective	Compulsory	Compulse	

	International Management and Engineering: Specialisation II. Mechatronics: Elective
	Compulsory International Management and Engineering: Specialisation II. Product Development and
	Production: Elective Compulsory
Assignment for the	Mechatronics: Core qualification: Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
	Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
	Compulsory
	Product Development, Materials and Production: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Compulsory

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

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

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Courses					
<b>Title</b>			Тур	Hrs/wk	СР
echnology Management	t (L0849)		Project-/problem-based Learning	3	3
echnology Management	t Seminar (L	0850)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Corr	nelius Herstatt			
Admission Requirements	None				
•	Bachelor	knowledge in business man	agement		
Educational Objectives	After takin	ng part successfully, students	s have reached the following lea	arning resu	lts
Professional Competence					
Knowledge	<ul> <li>International R&amp;D-Management</li> <li>Technology Timing Strategies         <ul> <li>Technology Strategies and Lifecycle Management (I/II)</li> <li>Technology Intelligence and Planning</li> </ul> </li> <li>Technology Portfolio Management         <ul> <li>Technology Portfolio Management</li> <li>Technology Portfolio Methodology</li> <li>Technology Acquisition and Exploitation</li> <li>IP Management</li> </ul> </li> <li>Organizing Technology Development         <ul> <li>Technology Organization &amp; Management</li> <li>Technology Funding &amp; Controlling</li> </ul> </li> </ul>				
Skills	<ul> <li>Develop an understanding of the importance of Technology Management - on national as well as international level</li> <li>Equip students with an understanding of important elements of Technolog Management (strategic, operational, organizational and process-related aspects)</li> <li>Foster a strategic orientation to problem-solving within the innovation process as w as Technology Management and its importance for corporate strategy</li> <li>Clarify activities of Technology Management (e.g. technology sourcing, maintenan and exploitation)</li> <li>Strengthen essential communication skills and a basic understanding of management organizational and financial issues concerning Technology-, Innovation- and R&amp; management. Further topics to be discussed include:</li> <li>Basic concepts, models and tools, relevant to the management of technology, R&amp; and innovation</li> <li>Innovation as a process (steps, activities and results)</li> </ul>				
Personal Competence		איזענוטוי מז מ אוטטבזג (גופאנ	, adaviado and reouno <i>)</i>		
Social Competence	<ul> <li>Interact within a team</li> <li>Raise awareness for globabl issues</li> </ul>				
	1				

Autonomy	<ul> <li>Discuss recent research debates in the context of Technology and Innovation Management</li> <li>Develop presentation skills</li> <li>Discussion of international cases in R&amp;D-Management</li> </ul>				
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following Curricula	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory				

Course L0849: Techno	ology Management		
Тур	Project-/problem-based Learning		
Hrs/wk	3		
СР	3		
Workload in Hours	ndependent 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: Techno	ology Management Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Courses						
<b>Title</b> Control Systems Theory a Control Systems Theory a			<b>Typ</b> Lecture Recitation Section	Hrs/v 2 (small) 2	vk	<b>CP</b> 4 2
Module Responsible						
Admission Requirements						
Recommended Previous Knowledge		ntrol Systems				
Educational Objectives	After taking part su	iccessfully, students I	nave reached the followi	ng learning	result	6
Professional Competence						
Knowledge	<ul> <li>Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space</li> <li>They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively</li> <li>They can explain the significance of a minimal realisation</li> <li>They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain state space models and transfer function models of discrete-time systems</li> <li>They can explain the experimental identification of ARX models of dynamic systems and how the identification problem can be solved by solving a normal equation</li> <li>They can explain how a state space model can be constructed from a discrete-time impulse response</li> </ul>					
Skills	<ul> <li>Students can transform transfer function models into state space models and versa</li> <li>They can assess controllability and observability and construct minimal realisations</li> <li>They can design LQG controllers for multivariable plants</li> <li>They can carry out a controller design both in continuous-time and discrete-tidomain, and decide which is appropriate for a given sampling rate</li> <li>They can identify transfer function models and state space models of dynamic syste from experimental data</li> <li>They can carry out all these tasks using standard software tools (Matlab Con Toolbox, System Identification Toolbox, Simulink)</li> </ul>					
Personal Competence						
Social Competence	Students can work	in small groups on s	pecific problems to arriv	e at joint solu	utions	
			from provided source d use it when solving giv	•		es, softwa
Autonomy	They can assess progress.	their knowledge in v	veekly on-line tests and	thereby co	ntrol t	heir learnir

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	t None
Examination	Written exam
Examination duration and scale	1120 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Aircraft Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

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

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

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Module M0867: F	Production Planning & Con	trol and Digital Ente	erprise		
Courses					
Title		Тур	Hrs/wk	СР	
The Digital Enterprise (L0	-	Lecture	2	2	
Production Planning and C Production Planning and C		Lecture	2 (amall) 1	2	
Exercise: The Digital Enter		Recitation Section Recitation Section		1 1	
-	,			I	
Admission	Prof. Hermann Lödding				
Requirements	None				
Recommended Previous Knowledge	Fundamentals of Production and Qu	ality Management			
Educational Objectives	After taking part successfully, studer	nts have reached the followi	ng learning resul	lts	
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					
	Students can develop joint solutions in mixed teams and present them to others.				
Autonomy					
	Independent Study Time 96, Study Time in Lecture 84				
Credit points					
Course achievement	l				
	Written exam				
Examination duration and scale	180 Minuten				
	International Management and Er	igineering: Specialisation	II. Product Deve	elopment and	
	Production: Elective Compulsory	ility: Specialisation Produ	ction and Logi	stics: Elective	
	Logistics, Infrastructure and Mobility: Specialisation 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: Specialisa				
Assignment for the	Compulsory				
Following Curricula	Curricula Biomedical Engineering: Specialisation Management and Business Admini			Administration	
<b>3 1 1</b>	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: Specialisation Product Development and Production:				
	Elective Compulsory				
	Theoretical Mechanical Engineering	: Technical Complementary	/ Course: Elective	e Compulsory	

Course L0932: The Dig	jital Enterprise		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	ndependent 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 Planning and Control				
Тур	Lecture			
Hrs/wk				
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Hermann Lödding			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Models of Production and Inventory Management</li> <li>Production Programme Planning and Lot Sizing</li> <li>Order and Capacity Scheduling</li> <li>Selected Strategies of PPC</li> <li>Manufacturing Control</li> <li>Production Controlling</li> <li>Supply Chain Management</li> </ul>			
Literature	<ul> <li>Vorlesungsskript</li> <li>Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008</li> <li>Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002</li> </ul>			

Course L0930: Production Planning and Control			
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	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: Exercis	ourse L0933: Exercise: The Digital Enterprise				
Тур	Recitation Section (small)				
Hrs/wk	1				
СР	1				
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14				
Lecturer	Dr. Axel Friedewald				
Language	DE				
Cycle					
Content	See interlocking course				
Literature	Siehe korrespondierende Vorlesung See interlocking course				

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## Module M0921: Electronic Circuits for Medical Applications Courses Title Hrs/wk СР Тур Electronic Circuits for Medical Applications (L0696) Lecture 2 3 Electronic Circuits for Medical Applications (L1056) Recitation Section (small) 1 2 Electronic Circuits for Medical Applications (L1408) **Practical Course** 1 1 Module Responsible Prof. Matthias Kuhl Admission None Requirements Recommended Fundamentals of electrical engineering **Previous Knowledge** Educational After taking part successfully, students have reached the following learning results Objectives Professional Competence 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 axon Students can exemplify the communication between neurons and electronic devices Students can describe the special features of low-noise amplifiers for medical Knowledge applications Students can explain the functions of prostheses, e.g. an artificial hand Students are able to discuss the potential and limitations of cochlea implants and artificial eyes 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. Skills Students can develop the block diagrams of prosthetic systems • Students can define the building blocks of electronic systems for an articifial eye. Personal Competence Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. Students are able to recognize their specific limitations, so that they can ask for assistance to the right time. Social Competence Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary • Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. Students can break down their work in appropriate work packages and schedule their work in a realistic way.

Students can handle the complex data structures of bioelectrical experiments without needing support.



	<ul> <li>Students are ab experimental work</li> </ul>		oonsible manr	ner in all cases and situations of
Workload in Hours	Independent Study Time	124, Study Time in	Lecture 56	
Credit points	6			
	Compulsory Bonus	Form		Description
Course achievement	Yes None	Subject theo practical work	retical and	
	No None	Excercises		
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: 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: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

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

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

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



Courses					
Title		Тур	Hrs/wk	СР	
Continuum Mechanics (L1533)		Lecture	2	3	
Continuum Mechanics Ex	ercise (L1534)	Recitation Section	(small) 2	3	
	Prof. Christian Cyron				
Admission Requirements	None				
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).				
Educational Objectives	After taking part successfully students	have reached the follow	ing learning resul	ts	
Professional					
Competence					
Knowledge	The students can explain the fundamental concepts to calculate the mechanical behavior o materials.				
Skills	The students can set up balance lav aspects, both in applied contexts as in		deformation the	ory to speci	
Personal					
Competence		iono to proport theory to a	a a cialista in uvitt	an farma and	
Social Competence	develop ideas further.	The students are able to develop solutions, to present them to specialists in written form and t develop ideas further.			
Autonomy	The students are able to assess independently and on their own ide mechanics and acquire the knowledge	entify and solve proble		•	
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 56			
Credit points	6				
Course achievement	None				
	Written exam				
Examination duration and scale	45 min				
Assignment for the Following Curricula	Compulsory Biomedical Engineering: Specialisatic Compulsory	ment: Specialisation Mate ary Course: Elective Com n Artificial Organs and R n Implants and Endopros on Medical Technology on Management and Bu	erials: Elective Co apulsory egenerative Med stheses: Elective and Control Th siness Administra	icine: Electiv Compulsory eory: Electiv ation: Electiv	
	Product Development, Materials and P	roduction: Core qualifica	tion: Elective Cor	npulsory	
	[010]				



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2 (cmall) 2	3 3
Material Modeling (L1536)		Recitation Section	n (small) 2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students h	ave reached the follow	ving learning resu	Its
Professional Competence				
Knowledge	The students can explain the fundamen	tals of multidimensiona	al consitutive mate	erial laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
eempetenee	The students are able to develop solu	utions, to present then	n to specialists a	nd to develop
Social Competence	ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points				
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Computational Science and Enginee Compulsory Materials Science: Specialisation Mode Mechanical Engineering and Managem Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Product Development, Materials and Pr Theoretical Mechanical Engineering: Specialise	ling: Elective Compuls ent: Specialisation Ma Artificial Organs and F Implants and Endopro n Medical Technology n Management and Bu poduction: Core qualific	ory terials: Elective Co Regenerative Mec ostheses: Elective y and Control Th usiness Administr ation: Elective Co	ompulsory dicine: Elective Compulsory neory: Elective ation: Elective

Course L1535: Materia	al Modeling
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: Materia	al Modeling
Тур	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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: A	Advanc	ed Functi	onal Mater	rials			
Courses							
<b>Title</b> Advanced Functional Mat	erials (L16	25)		-	<b>/p</b> eminar	Hrs/wk 2	<b>CP</b> 6
Module Responsible	Prof. Pat	rick Huber					
Admission Requirements	None						
Recommended Previous Knowledge		owledge in M	aterials Scienc	ce, e.g. Mate	rials Science	1/11	
Educational Objectives	After taki	ng part succe	essfully, studen	nts have reac	hed the follow	ving learning re	sults
Professional							
Competence	-	lanta will be	able to sure	in the ware	which of	nood material	- الد الله الم
Knowledge	applicati	ons in techno		ular metallic	, ceramic, po	anced materials lymeric, semico	•
Skills	and, if ne to the m	ecessary, to d nacroscale. Th nables them	esign new ma ne students w	terials consid vill also gain	dering archite an overview	ccording to the ectural principles and modern matching ons depending	from the micro aterials science
Personal Competence							
Social Competence	The stud	ents are able	to present solu	utions to spe	cialists and to	o develop ideas	further.
	The stud	ents are able	to				
Autonomy	∙a	ssess their ov	vn strengths ar cessary expert				
Workload in Hours	Indepen	dent Study Tir	me 152, Study	Time in Lect	ure 28		
Credit points	6						
Course achievement	None						
Examination	Presenta	ation					
Examination duration and scale	130 min						
Assignment for the Following Curricula	Mechani Biomedi Compuls Biomedi Biomedi Compuls Biomedi Compuls	cal Engineeri cal Engineeri cory cal Engineeri cal Engineeri cory cal Engineeri cory	ng: Specialisat ng: Specialisat ing: Specialisa ng: Specialisa	gement: Spec tion Artificial tion Implants ation Medica ation Manage	cialisation Ma Organs and I and Endopro al Technolog ement and B	terials: Elective Regenerative M ostheses: Electiv y and Control usiness Adminis	edicine: Electiv e Compulsory Theory: Electiv stration: Electiv
					•	ary Course: Elec Science: Electiv	•

Course L1625: Advand	ced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>
Literature	Wird in der Veranstaltung bekannt gegeben

Courses				
Title Introduction to Biochemist	try and Molecular Biology (L0386)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	NONE			
Educational Objectives	Attor taking nart successfully studen	its have reached the follow	ing learning resul	ts
Professional Competence				
Knowledge	<ul> <li>The students can</li> <li>describe basic biomolecules</li> <li>explain how genetic informat</li> <li>explain the connection between</li> </ul>	tion is coded in the DNA;		
Skills	<ul> <li>The students can</li> <li>recognize the importance of recognize selected molecular-</li> <li>explain the relevance of these</li> </ul>	-diagnostic procedures;		ease;
Personal Competence	The students can participate in dias	ussions in research and me	dicino on a tochn	
Social Competence Autonomy	The students can develop understat by themselves.			
Workload in Hours	Independent Study Time 62, Study T	ime in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
	General Engineering Science (Ge Engineering: Compulsory General Engineering Science (Ge Engineering, Focus Biomechanics: C Electrical Engineering: Specialisatio General Engineering Science (En Engineering, Focus Biomechanics: C General Engineering Science (En Engineering: Compulsory	rman program, 7 semest Compulsory In Medical Technology: Ele glish program, 7 semest Compulsory	er): Specialisation ctive Compulsory er): Specialisation	n Mechanic n Mechanic

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

IO I: Implants and Fracture Healing		
aling (L0376) Typ	Hrs/wk 2	<b>СР</b> 3
Prof. Michael Morlock		
None		
It is recommended to participate in "Introduction into Anato Fracture Healing".	omie" before attending '	'Implants ar
After taking part successfully, students have reached the for	ollowing learning result	S
existence.		
The students can determine the forces acting within t situations under specific assumptions.	he human body unde	r quasi-stat
The students can, in groups, solve basic numerical me internal forces.	odeling tasks for the c	calculation
The students can, in groups, solve basic numerical me internal forces.	odeling tasks for the o	calculation of
Independent Study Time 62, Study Time in Lecture 28		
3		
None		
Written exam		
90 min		
Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 se Engineering: Compulsory General Engineering Science (English program, 7 se Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 se Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: C Biomedical Engineering: Specialisation Artificial Organs a Compulsory Biomedical Engineering: Specialisation Implants and End	emester): Specialisation mester): Specialisation mester): Specialisation ompulsory and Regenerative Medi oprostheses: Elective C plogy and Control The	n Biomedic n Mechanic n Biomedic cine: Electiv compulsory eory: Electiv
	aling (L0376)       Lecture         Prof. Michael Morlock         None         It is recommended to participate in "Introduction into Anator Fracture Healing".         After taking part successfully, students have reached the for         The students can describe the different ways how bones existence.         The students can name different treatments for the spi fracture morphologies.         The students can, in groups, solve basic numerical more internal forces.         The students can, in groups, solve basic numerical more internal forces.         Independent Study Time 62, Study Time in Lecture 28         3         None         Written exam         90 min         General Engineering Science (German program, 7 set Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 set Engineering: Compulsory         General Engineering Science (English program, 7 set Engineering: Compulsory         Mechanical Engineering: Specialisation Artificial Organs a Compulsory	Typ         Hrs/wk           aling (L0376)         Lecture         2           Prof. Michael Morlock         None

.



Course L0376: Implant	ts and Fracture Healing
Тур	Lecture
Hrs/wk	2
СР	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Michael Morlock
Language	
Cycle	Topics to be covered include:
	<ol> <li>Introduction (history, definitions, background importance)</li> </ol>
	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
	<ul><li>3.5 Injuries and diseases</li><li>4. Pelvis (anatomy, biomechanics, fracture treatment)</li></ul>
Content	
Contoni	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
	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
Literature	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Module M1334: B	BIO II: Biomaterials
Courses	
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials
Personal Competence	
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
i	

Lecturer Language	Prof. Michael Morlock EN
Cycle	WiSe
	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
Content	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.
	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.
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	[324]

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer,
1996.

TUHH

Module	M1342:	Pol	ymers

Courses					
<b>Title</b> Structure and Properties of Processing and design with		<b>Typ</b> Lecture Lecture	Hrs/wk 2 2	<b>СР</b> 3 3	
Module Responsible	Dr. Hans Wittich				
Admission Requirements	None				
Recommended Previous Knowledge	Basics: chemistry / physics / materia	l science			
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ing learning resu	lts	
Professional Competence					
Knowledge	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).				
Skills	Students are capable of - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.				
Personal Competence					
Social Competence	Students can - arrive at funded work results in heterogenius groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively.				
Autonomy	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.				
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 56			
Credit points	6				
Course achievement					
Examination duration	Written exam 180 min				
and scale	Materials Science: Specialisation Er Biomedical Engineering: Specialisa			sory	

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective				
	Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective				
Assignment for the	Compulsory				
Following Curricula	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 Compulsory				
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory				

Course L0389: Structu	ire and Properties of Polymers			
Тур	Lecture			
Hrs/wk				
СР	3			
	Independent Study Time 62, Study Time in Lecture 28			
	Dr. Hans Wittich			
Language	DE			
Cycle	WiSe			
Content	<ul> <li>Structure and properties of polymers</li> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology <ul> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> <li>Applications</li> </ul> </li> </ul>			
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag			
Literature	Entensiem. Polymer-werksione, Carl Hanser Verlag			

Course L1892: Proces	sing and design with polymers		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich		
Language	DE/EN		
Cycle	le WiSe		
Content Manufacturing of Polymers: General Properties; Calendering; Extrusion; Injection Mou 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		

Madula M0C20. F		Inc			
MOQUIE MU632: F	Regenerative Medic	ine			
Courses					
<b>Title</b> Regenerative Medicine (L	0247)		<b>Typ</b> Seminar	Hrs/wk 2	<b>СР</b> 3
	ng - Regenerative Medicine (L	1664)	Seminar	2	3
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part successfu	Illy, students have re	eached the followi	ng learning resul	ts
Professional Competence					
Knowledge	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells. The students can outline the actual concepts of Tissue Engineering and regenerative				
	medicine and can explain the basic udnerlying principles of the discussed topics. After successful completion of the module students are				
Skills	<ul> <li>able to use medical databases for acquirierung and presentation of relevant up-to-date data independently</li> <li>able to present their work results in the form of presentations</li> <li>able to carry out basic cell culture methods and the corresponding analysis independently</li> <li>able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine.</li> </ul>				
Personal					
Competence					
	Students are able to wor discuss their results in the	-		ents to solve giv	ven tasks an
Social Competence	Students are able to reflect their work orally and discuss it with other students and teachers.				
Autonomy	After completion of this mo of approx. 2-4 persons inc				blem in team
	Independent Study Time 1	124, Study Time in L	ecture 56		
Credit points	·				
Course achievement	Compulsory BonusYes20 %	Form Written elaboration	Ausa	<b>cription</b> arbeitung zu Rir ocol for lecture se	
Examination	Presentation				
Examination duration and scale	Oral presentation + discus	ssion (30 min)			
and Sudle	I				

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Centrel Theory: Elective
Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

Course L1664: Lecture	e Tissue Engineering - Regenerative Medicine		
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts		
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; SBN-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		

Module M0548: E	Bioelectromagnetics	: Principles an	d Applications		
Courses					
Title			Тур	Hrs/wk	СР
-	ciples and Applications (L0371)		Lecture	3	5
_	ciples and Applications (L0373)	)	Recitation Section (small)	2	1
	Prof. Christian Schuster				
Admission Requirements	NONE				
Recommended Previous Knowledge					
Educational Objectives	Affer taking hart successful	lly, students have re	ached the following lea	rning resul	ts
Professional	<u> </u>				
Competence					
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.				
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.				
Personal Competence					
Social Competence	Students are able to work present their results effective				ey are able t
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points	· · · · · · · · · · · · · · · · · · ·	, , , <b>_</b>			
Course achievement		<b>Form</b> Presentation	Descriptio	n	

Examination			
Examination duration and scale	15 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		

Hrs/wk CP	Lecture 3
СР	3
Workload in Hours	5
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
	<ul> <li>Fundamental properties of electromagnetic fields (phenomena)</li> </ul>
	- 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
Content	- 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
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CI (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wi (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (200
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagne Fields", CRC (2006)

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

Module M0630: R	lobotics and	Naviga	ition in Medici	ine		
Courses						
Title				Тур	Hrs/wk	СР
Robotics and Navigation in Robotics and Navigation in				Lecture Project Seminar	2 2	3 2
Robotics and Navigation in	, ,			Project Seminar Recitation Section (small)		2
Module Responsible		chlaefer				
Admission Requirements						
Recommended Previous Knowledge		of progra	algebra, analysis/c mming, e.g., in Jav kills			
Educational Objectives	After taking part si	uccessful	ly, students have re	eached the following lea	rning resu	lts
Professional						
Competence						
Knowledge	systems and their	r compor	ents in detail. Sys	acking systems in clinica stems can be evaluated nts can assess typical sy	with respe	ect to collisi
Skills	The students are able to design and evaluate navigation systems and robotic systems f medical applications.					
Personal Competence	The students di	course th	a results of othe	r groups, provide bol	oful foodb	ack and a
Social Competence				r groups, provide hel	un ieedb	ack and c
Autonomy			neir knowledge an propriate manner.	d document the results	of their w	ork. They c
Workload in Hours	Independent Stud	dy Time 1	10, Study Time in L	ecture 70		
Credit points	6					
Course achievement	Compulsory BonYes10 %Yes10 %	%	<b>Form</b> Written elaboratior Presentation	Descriptic ו	on	
Fyamination	Written exam	, .				
Examination duration and scale						
	Electrical Enginee International Man Compulsory Mechatronics: Spe Biomedical Engin Compulsory Biomedical Engin	ering: Spe agement ecialisation neering: S neering: S	ecialisation Medica and Engineering: on Intelligent Syste pecialisation Artific pecialisation Impla	e Engineering: Elective ( I Technology: Elective ( Specialisation II. Electric ms and Robotics: Electric cial Organs and Regene ants and Endoprostheses dical Technology and (	compulsory cal Engine ve Compul trative Mec s: Elective	, ering: Electi sory licine: Electi Compulsory

Assignment for the	Biomedical Engineering: Specialisation Management and Business Administration: Elective
Following Curricula	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 Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective
	Compulsory
	Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsor Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective

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

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

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

## TUHH Hamburg University of Technology

Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical	Fechnology and Systems (LC	0342)	Lecture	2	3
Introduction into Medical Technology and Systems (L0343)			Project Seminar	2	2
Introduction into Medical	Fechnology and Systems (L1	876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefe	er			
Admission Requirements	None				
	principles of math (algeb	ra, analysis/calculus)	)		
Recommended	principles of stochastics				
Previous Knowledge	principles of programmin	ig, R/Matlab			
Educational Objectives		fully, students have re	eached the following lea	rning resul	ts
Professional					
Competence					
	The students can expla				
Knowledge	computer aided surgery,			able to giv	e an overvie
	of regulatory affairs and s	standards in medical	technology.		
	The students are able t	to evaluate systems	and medical devices i	n the cont	ext of clinic
Skills	applications.				
D	Ì				
Personal					
Personal Competence		problem in medical t	echnology as a project	and define	tasks that a
Competence	The students describe a	problem in medical t	echnology as a project,	and define	tasks that ar
Competence		problem in medical t	echnology as a project,	and define	tasks that ar
Competence Social Competence	The students describe a solved in a joint effort. The students can reflect	t their knowledge an	d document the results		
Competence Social Competence	The students describe a solved in a joint effort.	t their knowledge an	d document the results		
Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect	t their knowledge an appropriate manner.	d document the results		
Competence Social Competence Autonomy	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge an appropriate manner.	d document the results		
Competence Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time	t their knowledge an appropriate manner.	d document the results	of their w	
Competence Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b>	t their knowledge an appropriate manner. 110, Study Time in L	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b>	t their knowledge an appropriate manner. 110, Study Time in L Form	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 %	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboratior	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus Yes 10 % Yes 10 % Written exam	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboratior	ecture 70	of their w	
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam	t their knowledge an appropriate manner. 110, Study Time in L <b>Form</b> Written elaboration Presentation	ecture 70 Description	of their w	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation	ecture 70 Description	of their w	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y sialisation Computer a	Description Description Description	of their w	n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering: C	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele	Description Description Description Description Description Segram, 7 semester): Sp and Software Engineerin Software Engineerin	of their w	ork. They ca
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering: C General Engineering S	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y cialisation Computer a core qualification: Ele cience (English pro	Description Description Description Description Description Segram, 7 semester): Sp and Software Engineerin Software Engineerin	of their w	ork. They ca n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y sialisation Computer a core qualification: Ele cience (English pro y	Description Descri	of their w	n Biomedica Compulsory
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering: C General Engineering S	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering:	Description Descri	of their w	n Biomedica n Biomedica
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: Ilsory	Description Description Description Description Description N Description N Description N Description N Description N Specialisation II. Math	of their w	n Biomedica Compulsory n Biomedica Engineerin
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination duration and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: ilsory and Engineering:	Description Description Description Description Description Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N	of their w	n Biomedica Compulson n Biomedica compulson n Biomedica Engineerin
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory Computational Science	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: ilsory and Engineering:	Description Description Description Description Description Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N Description N	of their w	n Biomedic Compulsor n Biomedic Engineerir nce: Electiv
Competence Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflect present the results in an Independent Study Time 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulsor Computer Science: Spec Electrical Engineering S Engineering: Compulsor Computational Science Science: Elective Compu Computational Science Compulsory	t their knowledge an appropriate manner. 110, Study Time in L Form Written elaboration Presentation cience (German pro y stalisation Computer a core qualification: Ele cience (English pro y and Engineering: and Engineering: and Engineering:	bd document the results ecture 70 Description Description Description Description Description Specialisation Engineerin Specialisation II. Math Specialisation Comp Specialisation Engineering Specialisation Enging Specialisation Engineering S	of their w	n Biomedica compulsory n Biomedica Engineerin nce: Electiv

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

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

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

Courses					
<b>Title</b> Nonlinear Dynamics (L07	02)	<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Inear Algebra				
Educational Objectives	After taking part successfully, students ha	ve reached the following	learning resu	lts	
Professional Competence					
Knowledge	develop and research new terms and concepts.				
Skills	develop novel methods and procedures.				
Personal Competence					
-	I Students can reach working results also ii	n groups.			
Autonomy	Students are able to approach given research tasks individually and to identify and follow up				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
	Written exam				
Examination duration and scale	2 Hours				
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulso Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

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

Courses							
Title		Тур	Hrs/wk	СР			
Semiconductor Technolog		Lecture	4	4			
Semiconductor Technolog		Practical Course	2	2			
	Prof. Hoc Khiem Trieu						
Admission Requirements	None						
Recommended Previous Knowledge	Basics in physics, chemistry, n	naterial science and semiconducto	or devices				
Educational Objectives	After taking part successfully, s	students have reached the following	ng learning resu	lts			
Professional Competence							
	Students are able						
	• to describe and to explain current fabrication techniques for Si and GaAs substrates,						
Knowledge	• to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and						
	<ul> <li>to present integrated proce</li> </ul>	ess flows.					
	Students are capable						
	<ul> <li>to analyze the impact of process parameters on the processing results,</li> </ul>						
Skills							
		or the fabrication of semiconductor	devices.				
Personal Competence							
Social Competence	Students are able to prepare present and discuss the result	and perform their lab experimer s in front of audience.	ts in team work	as well as t			
Autonomy	None						
-	Independent Study Time 96, S	tudy Time in Lecture 84					
Credit points	6						
Course achievement	None						
Examination							
Examination duration							

Assignment for the Following Curricula	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
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory

Course L0722: Semico	onductor Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process)</li> <li>Wafer fabrication (process flow, specification, SOI)</li> <li>Fabrication processes</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>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, we chemical etching: isotropic and anisotropic, corner undercuting, compensation masks and etch sop techniques; dry etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, TAB and flip chip, wafer level package, 3D stacking)</li> </ul>

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

Courses										
<b>Title</b> Humanoid Robotics (L066	3)					<b>Typ</b> Seminar		Hrs/wk 2	<b>CP</b> 2	
Module Responsible	Patrick	Göttsch								
Admission Requirements	None									
Recommended Previous Knowledge			on to cont neory and	rol system design	IS					
Educational Objectives	After tak	king part	successfu	lly, studen	ts have re	eached the fo	llowing lea	arning resu	lts	
Professional Competence										
Knowledge			•	in humano pply basic		s. oncepts for d	ifferent tas	ks in huma	noid roboti	CS.
Skills	•	specified Students	literature generaliz	e develop	ed result	elected aspe s and presen a presentatic	t them to th			l 01
Personal Competence										
Social Competence	•	them	able to p			solutions in i e feedback a				
Autonomy	<ul> <li>Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution</li> <li>Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops</li> </ul>									
Workload in Hours	Indeper	ndent Stu	dy Time 3	2, Study T	ïme in Le	cture 28				
Credit points	2									
Course achievement										
Examination		tation								
Examination duration and scale	30 min									
Assignment for the Following Curricula	Mechati Biomed Compul Biomed	ronics: S lical Eng Isory lical Eng lical Eng	pecialisati neering: S neering: S	on System Specialisat	n Design: tion Artific	ms and Robo Elective Con cial Organs a ints and Endo dical Techno	npulsory nd Regene oprosthese	erative Mec es: Elective	licine: Elec Compulsor	ry

Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Title Linear and Nonlinear Syste Module Responsible					
Module Responsible	em Identification (L0660)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3	
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>Classical control (frequency response, root locus)</li> <li>State space methods</li> <li>Discrete-time systems</li> <li>Linear algebra, singular value decomposition</li> <li>Basic knowledge about stochastic processes</li> </ul>				
Educational Objectives	After taking part successfully, studen	ts have reached the follow	ving learning resu	lts	
Professional Competence					
Knowledge	<ul> <li>Students can explain the general framework of the prediction error method and i application to a variety of linear and nonlinear model structures</li> <li>They can explain how multilayer perceptron networks are used to model nonlinear dynamics</li> <li>They can explain how an approximate predictive control scheme can be based or neural network models</li> <li>They can explain the idea of subspace identification and its relation to Kalma realisation theory</li> </ul>				
Skills	<ul> <li>Students are capable of applying the predicition error method to the experiment identification of linear and nonlinear models for dynamic systems</li> <li>They are capable of implementing a nonlinear predictive control scheme based or neural network model</li> <li>They are capable of applying subspace algorithms to the experimental identification linear models for dynamic systems</li> <li>They can do the above using standard software tools (including the Matlab Syste Identification Toolbox)</li> </ul>				
Personal Competence					
Social Competence			-		
Autonomy	Students are able to find required i software documentation) and use it t	-	ovided (lecture no	ites, literatur	
Workload in Hours	Independent Study Time 62, Study T	ïme in Lecture 28			
Credit points					
Course achievement	None				
Examination	Oral exam				
Examination duration and scale	30 min				

	Mechatronics: Specialisation System Design: Elective Compulsory
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
Following Curricula	Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses						
<b>Title</b> Optimal and Robust Conti	ol (L06	58)	<b>Typ</b> Lecture		Hrs/wk 2	<b>СР</b> 3
Optimal and Robust Cont	-	-	Recitation Section	on (small) :	2	3
Module Responsible	Prof. H	Herbert Werner				
Admission Requirements	None					
Recommended Previous Knowledge	•	<ul> <li>Classical control (frequency response, root locus)</li> <li>State space methods</li> <li>Linear algebra, singular value decomposition</li> </ul>				
Educational Objectives	After ta	aking part successfully, stu	dents have reached the follo	wing lear	ning resul	lts
Professional Competence						
Knowledge	<ul> <li>Students can explain the significance of the matrix Riccati equation for the solution LQ problems.</li> <li>They can explain the duality between optimal state feedback and optimal state estimation.</li> <li>They can explain how the H2 and H-infinity norms are used to represent stability ar performance constraints.</li> <li>They can explain how an LQG design problem can be formulated as special case an H2 design problem.</li> <li>They can explain how model uncertainty can be represented in a way that lends itset to robust controller design</li> <li>They can explain how - based on the small gain theorem - a robust controller car guarantee stability and performance for an uncertain plant.</li> <li>They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities.</li> </ul>					
Skills	<ul> <li>Students are capable of designing and tuning LQG controllers for multivariable pl models.</li> <li>They are capable of representing a H2 or H-infinity design problem in the form of generalized plant, and of using standard software tools for solving it.</li> <li>They are capable of translating time and frequency domain specifications for con loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed sensitivity design.</li> <li>They are capable of constructing an LFT uncertainty model for an uncertain syster and of designing a mixed-objective robust controller.</li> <li>They are capable of formulating analysis and synthesis conditions as linear ma inequalities (LMI), and of using standard LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust controllox).</li> </ul>					
Personal Competence						
Social Competence		-	ps on specific problems to an	-		
Autonomy			ed information in sources p e it to solve given problems.	rovided (I	ecture no	otes, literatu

Workload in Hours
Credit points
Course achievement
Examination
Examination duration and scale
Assignment for the Following Curricula

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

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

Courses						
Title Marketing of Innovations (L2009)			<b>Typ</b> Lecture		Hrs/wk 4	<b>CP</b> 4
PBL Marketing of Innovati	ons (LO8	362)	Project-/p Learning	roblem-based	1	2
Module Responsible	Prof. C	hristian Lüthje				
Admission Requirements	None					
Recommended Previous Knowledge	•	Module International Busine Basic understanding of bus theory, project managemen Bachelor-level Marketing K Strategies, Basics of Buying Unerstanding the difference Understanding of the impor Good English proficiency; p	ness administration t, international busin nowledge (Marketin Behavior) s beweetn B2B and tance of managing ir	ess) g Instruments B2C marketir	s, Market an	nd Competit
Educational Objectives	After ta	king part successfully, stude	nts have reached the	e following lea	arning resul	ts
Professional Competence						
Knowledge	•	nts will have gained a deep of Specific characteristics in the Approaches for analyzing development The gathering of information Concepts and approaches service development proces Approaches and tools for products and innovative ser Marketing mix elements the challenges of innovative pro Pricing methods for new pro The organization of comple Communication concepts a	e marketing of innov the current mark n about future custom to integrate lead us ses ensuring customer-covices at take into conside oducts and services oducts and services x sales forces and per nd instruments for ne	et situation her needs and sers and their prientation in eration the sp ersonal selling ew products a	and the the the the the development of the development of the development of the the the development of the	future mark onts oproduct a pment of ne
Skills	• • •	on the acquired knowledge Design and to evaluate dec Analyze markets by applyin Conduct forecasts and deve Translate customer needs successfully apply advance development Use adequate methods to fo Choose suitable pricing stra Make strategic sales deci channels) Apply methods of sales force	isions regarding man g market and techno elop compelling scen s into concepts, pro- ed methods for cu oster efficient diffusio ategies and commun sions for products	keting and in logy portfolio arios as a ba ototypes and stomer-orient n of innovativ ication activiti and services	s sis for strate l marketab ted product re products es for innov s (i.e. selec	egic planning le offers and t and services and services vations
Personal						

Social Competence	<ul> <li>have fruitful discussions and exchange arguments</li> <li>develop original results in a group</li> <li>present results in a clear and concise way</li> <li>carry out respectful team work</li> </ul>			
Autonomy	<ul> <li>The students will be able to</li> <li>Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields.</li> <li>Consider proposed business actions in the field of marketing and reflect on them.</li> </ul>			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and scale	Written elaboration exercises presentation oral participation			
Assignment for the Following Curricula	<ul> <li>Global Technology and Innovation Management &amp; Entrepreneurship: Core qualification: Compulsory</li> <li>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory</li> <li>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</li> <li>Biomedical Engineering: Specialisation Management and Business Administration: Compulsory</li> </ul>			

TUHH

ourse L2009: Market				
⊺yp Hrs/wk	Lecture			
CP				
	Independent Study Time 64, Study Time in Lecture 56			
	Prof. Christian Lüthje			
Language				
Cycle				
Content	<ul> <li>Introduction</li> <li>Innovation and service marketing (importance of innovative products and service model, objectives and examples of innovation marketing, characteristics of service challenges of service marketing)</li> <li>II. Methods and approaches of strategic marketing planning <ul> <li>patterns of industrial development, patent and technology portfolios</li> </ul> </li> <li>III. Strategic foresight and scenario analysis <ul> <li>objectives and challenges of strategic foresight, scenario analysis, Delphi method</li> </ul> </li> <li>IV. User innovations <ul> <li>Role of users in the innovation process, user communities, user innovation toolki lead users analysis</li> </ul> </li> <li>V. Customer-oriented Product and Service Engineering <ul> <li>Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting</li> </ul> </li> <li>VII. Pricing <ul> <li>Basics of Pricing, Value-based pricing, Pricing models</li> </ul> </li> <li>VIII. Sales Management</li> <li>Basics of Sales Management, Assessing Customer Value, Planning Customer Visits</li> </ul>			
	<ul> <li>IX. Communications</li> <li>Diffusion of Innovations, Communication Objectives, Communication Instruments</li> <li>Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and</li> </ul>			
Literature	<ul> <li>innovations, third edition, Pearson education. ISBN-10: 1292040335 . Chapter 6 (188-21 Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).</li> <li>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw H Boston et al., 2008</li> <li>Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great First to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.</li> <li>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4<sup>th</sup> edition, Boston et a McGraw Hill</li> <li>Tidd; J. &amp; Hull, Frank M. (Editors) (2007) Service Innovation, London</li> <li>Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press</li> </ul>			

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

Module M1143: N	lechanical Design Me	thodology		
Courses				
<b>Title</b> Mechanical Design Metho Mechanical Design Metho		<b>Typ</b> Lecture Recitation Section (srr	Hrs/wk 3 nall) 1	<b>CP</b> 4 2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	students have reached the following	learning resu	lts
Professional Competence <i>Knowledge</i>	Science-based working on pr design techniques	roduct design considering targeted ap	oplication of s	pecific produc
	Creative handling of processes used for scientific preparation and formulation of comple product design problems / Application of various product design techniques followin theoretical aspects.			
Personal Competence				
Social Competence				
Autonomy Workload in Hours	Independent Study Time 124,	Study Time in Lecture 56		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula				licine: Electiv Compulsory leory: Electiv ation: Electiv nd Productior

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

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

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering -	Fundamentals (L0841)	Lecture	2	3
Bioprocess Engineering- I		Recitation Section (large)		1
	Fundamental Practical Course (L0843)	Practical Course	2	2
Module Responsible Admission				
Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", mod	ule "fundamentals for process	engineerir	ıg"
Educational Objectives	After taking part successfully, students h	nave reached the following lea	rning resul	lts
Professional				
Competence				
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstrean processing in detail.			
Skills	<ul> <li>describe different kinetic approaches for growth and substrate-uptake and to calculat the corresponding parameters</li> <li>predict qualitatively the influence of energy generation, regeneration of redo equivalents and growth inhibition on the fermentation process</li> <li>analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flu equations</li> <li>distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply the to current biotechnical problem</li> <li>propose solutions to complicated biotechnological problems and to deduce th corresponding models</li> <li>to explore new knowledge resources and to apply the newly gained contents</li> <li>identify scientific problems with concrete industrial use and to formulate solutions.</li> </ul>			
Personal Competence	After completion of this module partici	panta chauld ha abla ta dabai	to toobaica	
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.			
Autonomy	After completion of this module particip independently by organizing their work			
Workload in Hours	Independent Study Time 96, Study Time	e in Lecture 84		
Credit points	6			

	practical work
	Written exam
Examination duration and scale	90 min
-	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, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: 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 Process Engineering: Core qualification: Compulsory

Typ	Lecture	
Hrs/wk		
CP		
	ndependent Study Time 62, Study Time in Lecture 28	
	Prof. Andreas Liese, Prof. An-Ping Zeng	
Language		
Cycle		
Content	<ul> <li>Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese)</li> <li>Transport process in a bioreactor (Prof. Zeng)</li> <li>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fe batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese)</li> <li>Downstream technology in biotechnology: cell breakdown, zentrifugation, filtratic aqueous two phase systems (Prof. Liese)</li> </ul>	
Literature	<ul> <li>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wile VCH, 2012</li> <li>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</li> <li>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Pres 2010</li> <li>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor &amp; Francis, 1997</li> <li>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</li> </ul>	

Course L0842: Bioproe	cess Engineering- Fundamentals		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	1		
Workload in Hours	dependent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language			
Cycle			
Content	<ol> <li>Introduction (Prof. Liese, Prof. Zeng)</li> <li>Enzymatic kinetics (Prof. Liese)</li> <li>Stoichiometry I + II (Prof. Liese)</li> <li>Microbial Kinetics I+II (Prof. Zeng)</li> <li>Rheology (Prof. Liese)</li> <li>Mass transfer in bioprocess (Prof. Zeng)</li> <li>Continuous culture (Chemostat) (Prof. Zeng)</li> <li>Sterilisation (Prof. Zeng)</li> <li>Downstream processing (Prof. Liese)</li> <li>Repetition (Reserve) (Prof. Liese, Prof. Zeng)</li> </ol>		
Literature	siehe Vorlesung		

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

IED I: Introduction to Anotomy			
L0384) Typ Hrs/wk C Lecture 2 3	Р		
Prof. Udo Schumacher			
None			
None			
After taking part successfully, students have reached the following learning results			
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.			
The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explain the relevance of structures and their functions in the context of widespread diseases.			
The students can participate in current discussions in biomedical research and medicine on a professional level.			
The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the relevant knowledge themselves.			
Independent Study Time 62, Study Time in Lecture 28			
3			
None			
Written exam			
90 minutes			
General Engineering Science (German program, 7 semester): Specialisation Biomedica Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering: Compulsory General Engineering: Science (English program, 7 semester): Specialisation Biomedica Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
	Lecture         2         3           Prof. Udo Schumacher         None         None         None           None         Sonone         None         Sonone         None         Sonone         Sonone         Sonone         Sonone         Sonone         Sonone         Sonone         Sonone         Socialisation Medical Technology: Elective Compulsory         Soeanetal Engineering Science (Ge		

Hrs/wk 2 CP 3	3			
СРЗ	3			
Workload in Hours	ndependent Stu	3		
WOI RIOAU III HOUI S	Independent Study Time 62, Study Time in Lecture 28			
Lecturer F	Prof. Tobias Lang	ge		
Language	DE			
Cycle S				
C	General Anatom	у		
1	l <sup>st</sup> week:	The Eucaryote Cell		
	and i	-		
2	2 <sup>nd</sup> week:	The Tissues		
3	B <sup>rd</sup> week:	Cell Cycle, Basics in Development		
4	4 <sup>th</sup> week:	Musculoskeletal System		
5	5 <sup>th</sup> week:	Cardiovascular System		
6	6 <sup>th</sup> week:	Respiratory System		
	7 <sup>th</sup> week:	Genito-urinary System		
Content 8	B <sup>th</sup> week:	Immune system		
9	9 <sup>th</sup> week:	Digestive System I		
1	10 <sup>th</sup> week:	Digestive System II		
1	11 <sup>th</sup> week:	Endocrine System		
1	12 <sup>th</sup> week:	Nervous System		
1	13 <sup>th</sup> week:	Exam		
	Adolf Faller/Micl Stuttgart, 2012	nael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag		

Courses					
Fitle ntroduction to Radiology a	and Radiation Therapy (L0383)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3	
Module Responsible					
Admission Requirements					
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successfully, studer	its have reached the follow	ving learning resu	lts	
Professional Competence					
	<b>Therapy</b> The students can distinguish different in radiation therapy.	nt types of currently used e	equipment with res	spect to its u	
	The students can explain treatme contexts (e.g. surgery, internal medie	•	ion therapy in in	terdisciplina	
	The students can describe the pa follow-up care.	tients' passage from the	ir initial admittan	ce through	
	Diagnostics				
Knowledge	The students can illustrate the technical base concepts of projection radiography, includin angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).				
	The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.				
	The students can choose the right transmission and needs.	eatment method dependir	ng on the patient's	clinical histo	
	The student can explain the influence	e of technical errors on th	e imaging techniqi	ues.	
	The student can draw the right con error protocol.	clusions based on the im	ages' diagnostic f	indings or t	
	<b>Therapy</b> The students can distinguish curativ that conclusion.	e and palliative situations	and motivate why	r they came	
	The students can develop adequate aspects.	e therapy concepts and re	late it to the radia	tion biologio	
	The students can use the therapeuti	c principle (effects vs adve	erse effects)		
Skills	The students can distinguish different kinds of radiation, can choose the best one dependin 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 a second			

	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.
Personal Competence	
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine. The students are able to access anatomical knowledge by themselves, can participate competently 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	3
Course achievement	None
	Written exam
Examination duration and scale	90 minutes
-	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, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introdu	ction to Radiology and Radiation Therapy	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring	
Language	)E	
Cycle	oSe	
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments	

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Literature	<ul> <li>"Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999</li> <li>"Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –</li> <li>4. Auflage - Verlag Urban &amp; Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1</li> <li>"Strahlentherapie und Onkologie für MTA-R" von R. Sauer – 5. Auflage 2003 - Verlag Urban &amp; Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6</li> <li>"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus 8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8</li> <li>"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</li> <li>"Praxismanual Strahlentherapie" von Stöver / Feyer – 1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000</li> </ul>

Courses				
<b>Fitle</b> ntroduction to Physiology	(L0385)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students ha	ave reached the follow	ving learning resul	ts
Professional Competence	The students can			
Knowledge	<ul> <li>describe the basics of the energy metabolism:</li> </ul>			
Skills	The students can describe the effects of processing of information, development technical systems.	•	• •	
Personal Competence				
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical ar metrological.			
Autonomy	The students can derive answers to questions arising in the course and other physiologic areas, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following Curricula	General Engineering Science (German Engineering: Compulsory General Engineering Science (German Engineering, Focus Biomechanics: Com Electrical Engineering: Specialisation Me General Engineering Science (English Engineering, Focus Biomechanics: Com General Engineering Science (English Engineering: Compulsory Mechanical Engineering: Specialisation Biomedical Engineering: Specialisation	n program, 7 semest pulsory edical Technology: Ele program, 7 semest pulsory program, 7 semest Biomechanics: Comp	ter): Specialisatio ective Compulsory er): Specialisation ter): Specialisation ulsory	n Mechanio n Mechanio n Biomedio

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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



Module M1332: B	BIO I: Experimental Methods	in Biomechanics			
Courses					
Title		Тур	Hrs/wk	СР	
Experimental Methods in I	Biomechanics (L0377)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	It is recommended to participate "Experimentelle Methoden".	in "Implantate und Fral	kturheilung" bef	ore attendin	
Educational Objectives	After taking part successfully, students	have reached the followi	ng learning resu	lts	
Professional Competence					
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under giver fracture morphologies. 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 ir biomechanics.				
Personal Competence	-				
Social Competence					
Autonomy	The students can, in groups, solve bas	sic experimental tasks.			
	Independent Study Time 62, Study Tin	ne in Lecture 28			
Credit points					
Course achievement					
Examination Examination duration and scale	90 min				
Assignment for the Following Curricula	General Engineering Science (Germ Engineering, Focus Biomechanics: Co General Engineering Science (Germ Engineering: Compulsory General Engineering Science (Engl Engineering, Focus Biomechanics: Co General Engineering Science (Engl Engineering: Compulsory Mechanical Engineering: Specialisatio Biomedical Engineering: Specialisatio Compulsory Biomedical Engineering: Specialisatio Biomedical Engineering: Specialisatio Biomedical Engineering: Specialisatio Biomedical Engineering: Specialisatio Compulsory Biomedical Engineering: Specialisatio Compulsory Biomedical Engineering: Specialisatio Compulsory Biomedical Engineering: Specialisatio Compulsory Technomathematics: Specialisation III	ompulsory nan program, 7 semeste ish program, 7 semeste ompulsory ish program, 7 semeste on Biomechanics: Compu on Artificial Organs and Re on Implants and Endopros ion Medical Technology on Management and Bus	er): Specialisatio er): Specialisatio er): Specialisatio lsory egenerative Med and Control Th siness Administr	on Biomedica n Mechanica on Biomedica licine: Electiv Compulsory eory: Electiv ation: Electiv	

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

Module M1335: B	BIO II: Artificial Joint R	eplacement			
Courses					
Title	. (1. 1000)	Тур	Hrs/wk	СР	
Artificial Joint Replacemen		Lecture	2	3	
	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous Knowledge	Basic knowledge of orthoped	lic and surgical techniques is recor	mmended.		
Educational Objectives	After taking part successfully,	students have reached the followi	ng learning resu	lts	
Professional					
Competence	The students can some the d	ifferent kinde of estificial limbe			
Knowledge	nne sludents can name the d	ifferent kinds of artificial limbs.			
Skills	The students can explain endoprotheses.	the advantages and disadva	ntages of differ	ent kinds o	
Personal					
Competence	The students are able to dia	and include values of the analog value		mataa and tha	
Social Competence	The students are able to discuss issues related to endoprothese with student mates and the teachers.				
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.				
Workload in Hours	I Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	90 min				
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Orientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory				

Course L1306: Artificia	al Joint Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	
	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker satzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)
	<ol> <li>DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite Evolution der Implantate)</li> </ol>
Content	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)
	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
Literature	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

Module M0845: F	eedback Control in Medi	cal Technology				
Courses						
<b>Title</b> Feedback Control in Medi	cal Technology (L0664)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3		
Module Responsible						
Admission Requirements	None					
Recommended Previous Knowledge	Basics in Control, Basics in Physic	blogy				
Educational Objectives	After taking part successfully, stud	ents have reached the followi	ng learning resu	lts		
Professional Competence						
	The lecture will introduce into the point of view. Fundamentals in hu in control theory.	-				
Knowledge	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system fo example in for anesthesia control.					
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.					
Skills	Application of modeling, identification, control technology in the field of medical technology.					
Personal						
Competence						
Social Competence	Students can develop solutions to specific problems in small groups and present their results					
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.					
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28					
Credit points	3					
Course achievement	None					
Examination						
Examination duration and scale	20 min					
Assignment for the Following Curricula	Biomedical Engineering: Speciali	ation Control and Power S sation Implants and Endopros sation Artificial Organs and R	Systems Enginee stheses: Elective egenerative Med	ering: Elective Compulsory licine: Elective		
	Compulsory Biomedical Engineering: Specialis	sation Medical Technology ar	nd Control Theory	/: Compulsory		

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

# Module M0832: Advanced Topics in Control

Title		Тур	Hrs/wk	СР
Advanced Topics in Contr	ol (L0661)	Lecture	2	3
Advanced Topics in Control (L0662)		Recitation Sectio	n (small) 2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sen	sitivity design, linear matri	x inequalities	
Educational Objectives	After taking part successfully, studen	its have reached the follow	ving learning resu	lts
Professional Competence				
	<ul> <li>Students can explain the scheduling approach</li> <li>They can explain the repressivems</li> <li>They can explain how stabil formulated as LMI conditions</li> <li>They can explain how grid synthesis problems for LPV s</li> <li>They are familiar with polyto the basic synthesis technique</li> </ul>	sentation of nonlinear sy lity and performance con dding techniques can b systems pic and LFT representatic	stems in the form ditions for LPV sy e used to solve ons of LPV system	of quasi-Ll ystems can analysis a s and some
Knowledge	<ul> <li>Students can explain how communication topology of m</li> <li>They can explain the converg</li> <li>They can explain analysis involving either LTI or LPV age</li> </ul>	nultiagent systems gence properties of first o and synthesis conditio	rder consensus pr	otocols
	<ul> <li>Students can explain the sta systems that are discretized a</li> <li>They can explain (in outlin distributed systems and the a</li> </ul>	according to an actuator/s ne) the extension of the	ensor array bounded real le	emma to su
	<ul> <li>Students are capable of con mixed-sensitivity design of polytopic, LFT or general LP<sup>1</sup></li> <li>They are able to use standa tasks</li> </ul>	gain-scheduled control V models	lers; they can o	do this usi
Skills	<ul> <li>Students are able to design either LTI or LPV dynamics, u</li> </ul>			of agents w
	<ul> <li>Students are able to design of using the Matlab MD-toolbox</li> </ul>		patially interconn	ected systen

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0661: Advanc	ed Topics in Control
Тур	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling         <ul> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> </ul> </li> <li>Control of Multi-Agent Systems         <ul> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> </ul> </li> <li>Control of Spatially Interconnected Systems         <ul> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Multidimensional systems in Roesser state space form</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul> </li></ul>
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>

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

# Specialization Medical Technology and Control Theory

Module M0623: Ir	telligent System	s in Medicine			
	nemgent System	S III MEdicine			
Courses					
Title			Тур	Hrs/wk	СР
Intelligent Systems in Mec			Lecture	2	3
Intelligent Systems in Mec			Project Seminar	2	2
Intelligent Systems in Mec	icine (L0333)		Recitation Section (small)	1	1
	Prof. Alexander Schlae	fer			
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>principles of sto</li> </ul>	ogramming, Java/C++ a			
Educational Objectives	After taking part succes	sfully, students have re	eached the following lea	Irning resu	lts
Professional					
Competence					
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
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 helpful feedback and can incoorporate feedback into their work.				
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tim	ie 110, Study Time in L	ecture 70		
Credit points	6				
Course achievement	Compulsory BonusYes10 %Yes10 %	<b>Form</b> Written elaboration Presentation	Descriptio	on	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Electrical Engineering:	Specialisation Medical	e Engineering: Elective ( I Technology: Elective C ecialisation Systems Er	Compulsory	/

Assignment for the Following Curricula	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 Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0331: Intelligent Systems in Medicine		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>methods for search, optimization, planning, classification, regression and prediction in a clinical context</li> <li>representation of medical knowledge</li> <li>understanding challenges due to clinical and patient related data and data acquisition</li> <li>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</li> </ul>	
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	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Alexander Schlaefer	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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

#### TUHH Hamburg University of Technology

### Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

Title		Тур	Hrs/wk	СР
	ents and Cognitive Robotics (L0341) ents and Cognitive Robotics (L0512)	Lecture Recitation Section (small)	2	4 2
		Recitation Section (Smail)	2	2
Module Responsible Admission Requirements				
Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	After taking part successfully, students	have reached the following lea	rning resu	lts
Professional Competence				
Knowledge	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 identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. 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.			
Skills	Students can select an appropriate scenarios. For simplified agent applica optimization techniques. For those networks/dynamic Bayesian networks Students can also name and apply scenarios. For simple and complex de policies for concrete settings. In mul- finding different equilibria states,e.g. students will apply different voting proto	tion students can derive decisi e applications they can and apply bayesian reason different sampling techniqu cision making students can co ti-agent situations students w , Nash equilibria. For multi-	on trees an also creat ing for si es for sin mpute the ill apply t agent dec	nd apply bas ate Bayesi mple querie nplified age best action echniques cision maki
Personal Competence				
Social Competence	Students are able to discuss their sol English	utions to problems with other	s. They co	ommunicate
Autonomy	Students are able of checking their und concrete problems	derstanding of complex conce	ots by solv	ing varaints
Workload in Hours	Independent Study Time 124, Study Tir	ne in Lecture 56		
Credit points	6			
Course achievement	None			

and scale	
-	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: 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 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Jourse L0341: Intellige	ent Autonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul> <li>Definition of agents, rational behavior, goals, utilities, environment types</li> <li>Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minima algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty: Motivation: agents with no direct access to the state(s) of the environmen probabilities, conditional probabilities, product rule, Bayes rule, full joint probabilit distribution, marginalization, summing out, answering queries, complexity independence assumptions, naive Bayes, conditional independence assumptions</li> <li>Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference b enumeration), typical-case complexity, pragmatics: reasoning from effect (that can b perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynami 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</li> <li>Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio</li> <li>Complex decisions: sequential decision problems, value iteration, policy iteratior MDPs</li> <li>Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs dynamic decisions and Mapping</li> <li>Planning</li> <li>Game theory (Golden Balls: Split or Share)</li> <li>Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium</li> <li>Social Choice</li> <li>Voting protocols, preferences, paradoxes, Arrow's Theorem,</li> <li>Mechanism Design</li> <li>Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard Satterthwaite Impossibility Theorem, Direct mechanisms, expected externalit mechanisms, particip</li></ul>
Literature	<ol> <li>Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17</li> <li>Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005</li> <li>Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoa Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009</li> </ol>

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

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

Courses			
Title	Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	Atter 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 Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

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

Course L1669: Introdu	ction to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	
Cycle	
Content	<ul> <li>Most important types of waveguides and their properties</li> <li>Radiation and basic antenna parameters</li> <li>Most important types of antennas and their properties</li> <li>Numerical techniques and CAD tools for waveguide and antenna design</li> <li>Fundamentals of Electromagnetic Compatibility</li> <li>Coupling mechanisms and countermeasures</li> <li>Shielding, grounding, filtering</li> <li>Standards and regulations</li> <li>EMC measurement techniques</li> </ul>
Literature	<ul> <li>Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

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

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

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

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

Course L1890: Seminar Biomedical Engineering	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and 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
СР	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	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>
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 M	echanics II
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration	
and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, softwarebeispiele. Vieweg+Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>

Course L1820: System Simulation	
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<ul> <li>All participants must bring a notebook, to install and use the software OpenModelica.</li> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>

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

Course L0379: Ceram	ics Technology	
Тур	Lecture	
Hrs/wk	( <u>2</u>	
СР	3	
Workload in Hours	Independent Study Time 62	, Study Time in Lecture 28
Examination Form		
Examination duration and scale	90 Minuten	
	Dr. Rolf Janßen	
Language		
Cycle	WiSe	
	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder-based processing, e.g. "powder-metauurgica techniques and sintering (soild state and liquid phase). Also, some aspects of glass 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
Content		3. Powder fabrication
		4. Powder processing
		5. Shape-forming processes
		6. Densification, sintering
		7. Glass and Cement technology
		8. Ceramic-metal joining techniques
		te Caramiae", John Wiley & Cana Naw York 1075
		to Ceramics", John Wiley & Sons, New York, 1975
	ASM Engineering Materials	Handbook Vol.4 "Ceramics and Glasses", 1991
Literature	D.W. Richerson, "Modern C	eramic 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	СР
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Six Sigma (L1130)	Lecture	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3

	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 Curricula	I Riamadical Fudinaaring' Spacialication Madical Lachnology and Control Lhaary' Flactival

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

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

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

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

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

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

Course L1890: Seminar Biomedical Engineering	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and scale	schriffliche 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	
СР	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	<ul> <li>Introduction and structuring</li> <li>Basic terms of quality management</li> <li>Measuring and inspection equipment</li> <li>Tools of quality management: FMEA, QFD, FTA, etc.</li> <li>Quality management methodology Six Sigma, DMAIC</li> </ul>	
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 M	echanics II
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul> <li>Differential equations for momentum-, heat and mass transfer</li> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> <li>Coupling of momentum and heat transfer - Thermal Process Engineering</li> <li>Rheology – Bioprocess Engineering</li> <li>Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering</li> <li>Flow threw porous structures - heterogeneous catalysis</li> <li>Pumps and turbines - Energy- and Environmental Process Engineering</li> <li>Wind- and Wave-Turbines - Renewable Energy</li> <li>Introduction into Computational Fluid Dynamics</li> </ul>
Literature	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994.</li> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> <li>Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.</li> <li>Kuhlmann, H.C.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.</li> <li>Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.</li> <li>Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.</li> <li>Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.</li> <li>van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> </ol>

Course L1820: System	n Simulation		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and scale	30 min		
Lecturer	Dr. Stefan Wischhusen		
Language	DE		
Cycle	WiSe		
Content	<ul> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Heat transfer</li> <li>Example: System with different subsystems</li> </ul>		
Literature	<ol> <li>Modelica Association: "Modelica Language Specification - Version 3.3", Linköping, Sweden, 2012</li> <li>M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</li> <li>M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</li> </ol>		

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

Course L0379: Ceram	Course L0379: Ceramics Technology			
Тур	Lecture			
Hrs/wk	2			
СР	<u>3</u>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form				
Examination duration and scale	90 Minuten			
	Dr. Rolf Janßen			
Language				
Cycle	WiSe			
	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder-based processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be 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		
Content		3. Powder fabrication		
		4. Powder processing		
		5. Shape-forming processes		
		6. Densification, sintering		
		7. Glass and Cement technology		
	8. Ceramic-metal joining techniques			
	יט.ש. אוווטפוץ, "Introduction ו	to Ceramics", John Wiley & Sons, New York, 1975		
	ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991			
Literature	D.W. Richerson, "Modern C	eramic Engineering", Marcel Decker, New York, 1992		
	Skript zur Vorlesung			

Module M0746: N					
Courses					
F <b>itle</b> ⁄licrosystem Engineering	(L0680)		<b>Typ</b> Lecture	<b>Hrs/wk</b> 2	<b>CP</b> 4
<i>l</i> icrosystem Engineering	(L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	None				
Recommended Previous Knowledge	Basic courses in physics	, mathematics and e	lectric engineering		
Educational Objectives	After taking part success	fully, students have r	reached the following lea	arning resul	ts
Professional					
Competence Knowledge	The students know abou their applications in sens		t technologies and mate	rials of ME	MS as well
Skills	Students are able to ana to evaluate the potential		e functional behaviour of	f MEMS co	mponents a
Personal					
Competence					
Competence Social Competence	Students are able to sol	ve specific problem	s alone or in a group a	nd to prese	ent the resu
Social Competence	Students are able to sol	uire particular know	ledge using specialized l		
Social Competence Autonomy	Students are able to sol accordingly. Students are able to acq	uire particular know edge with other field	ledge using specialized l ls.		
Social Competence Autonomy	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time	uire particular know edge with other field	ledge using specialized l ls.		
Social Competence Autonomy Workload in Hours	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time	uire particular know edge with other field	ledge using specialized l ls.	literature a	
Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time 6 Compulsory Bonus	uire particular know edge with other field 124, Study Time in <b>Form</b>	ledge using specialized l ls. Lecture 56	literature a	
Social Competence Autonomy Workload in Hours Credit points Course achievement	Students are able to sol accordingly. Students are able to acq and associate this knowl Independent Study Time 6 Compulsory Bonus No 10 % Written exam	uire particular knowl edge with other field 124, Study Time in <b>Form</b> Presentation	ledge using specialized l ls. Lecture 56 <b>Descriptic</b>	literature a	



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Typ       Lecture         Hrs/wt       2         CP       4         Workload in Hours       Independent Study Time 92, Study Time in Lecture 28         Lecture       Prof. Manfred Kasper         Language       EN         Cycle       WiSe         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         Microsystementwurf, Springer (2000)       Microsystementwurf, Springer (2000)	ourse L0680: Microsystem Engineering				
CP       4         Workload in Hours       Independent Study Time 92, Study Time in Lecture 28         Lecturer       Prof. Manfred Kasper         Language       EN         Cyctel       WiSe         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         M. Kasper: Mikrosystementwurf, Springer (2000)       Heretree	Тур	Lecture			
Workload in Hours         Independent Study Time 92, Study Time in Lecture 28           Lecturer         Prof. Manfred Kasper           Language         EN           Cycle         WiSe           Object and goal of MEMS         Scaling Rules           Lithography         Film deposition           Structuring and etching         Energy conversion and force generation           Electromagnetic Actuators         Reluctance motors           Viscale         Digraph y           Signal detection and signal processing           Mechanical and physical sensors           Acceleration sensor, pressure sensor           Sensor arrays           System integration           Yield, test and reliability	Hrs/wk				
Lecturer       Prof. Manfred Kasper         Language       EN         Cycle       WiSe         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	СР				
Language       EN         Cycle       WiSe         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	Workload in Hours	ndependent Study Time 92, Study Time in Lecture 28			
Cycle       WISe         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         M. Kasper: Mikrosystementwurf, Springer (2000)					
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         M. Kasper: Mikrosystementwurf, Springer (2000)					
Scaling Rules Lithography Film deposition Structuring and etching Energy conversion and force generation Electromagnetic Actuators Reluctance motors 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 M. Kasper: Mikrosystementwurf, Springer (2000)	Cycle				
Yield, test and reliability M. Kasper: Mikrosystementwurf, Springer (2000)	Content	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			
	Literature				

ourse L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	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	

Courses					
<b>Title</b> Vibration Theory (L0701)		<b>Typ</b> Integrated Lecture	Hrs/wk 4	<b>CP</b> 6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Inear Algebra				
Educational Objectives	After taking part successfully, students ha	we reached the following	learning resu	Its	
Professional Competence					
Knowledge	Students are able to denote terms and co	oncepts of Vibration Theor	y and develo	p them furth	
Skills	Students are able to denote methods of V	ibration Theory and deve	lop them furth	ner.	
Personal					
Competence	Students can reach working results also	n droupe			
	Students are able to approach individual		ion Theory.		
-	Independent Study Time 124, Study Time	•	j:		
Credit points					
Course achievement					
Examination	Written exam				
Examination duration and scale	12 Hours				
-	Energy Systems: Core qualification: Elect International Management and Engin Compulsory Mechanical Engineering and Management Mechatronics: Core qualification: Compu- Biomedical Engineering: Specialisation A Compulsory Biomedical Engineering: Specialisation A Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Product Development, Materials and Pro Naval Architecture and Ocean Engineering Theoretical Mechanical Engineering: Co Theoretical Mechanical Engineering: Teo	neering: Specialisation nt: Specialisation Mechate Isory Artificial Organs and Rege mplants and Endoprosthe Medical Technology an Management and Busine duction: Core qualification ng: Core qualification: Ele re qualification: Elective C	ronics: Electiv enerative Mec ses: Elective d Control Th ess Administr a: Compulsory ctive Compuls ompulsory	re Compulso licine: Electi Compulsory leory: Electi ation: Electi v sory	

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

2011/2000						
Courses				, .		
<b>Title</b> Microsystems Technolog <u>y</u>	v (1 0724)		<b>yp</b> ecture	Hrs/wk 2	<b>CP</b> 4	
Microsystems Technolog		P	roject-/problem-based	2	2	
Module Responsible	Learning					
Admission Requirements	None					
Recommended Previous Knowledge	Basics in physics, chemistry, m	echanics and ser	niconductor technolog	ду		
Educational Objectives	After taking part successfully, s	tudents have read	ched the following lea	rning resul	ts	
Professional						
Competence	Students are able					
<ul> <li>to present and to explain current fabrication techniques for methods for the fabrication of microsensors and microactuato thereof in more complex systems</li> </ul>			•		•	
Knowledge	to explain in details operation principles of microsensors and microactuators and					
	• to discuss the potential and limitation of microsystems in application.					
	<ul> <li>Students are capable</li> <li>to analyze the feasibility of</li> </ul>	microsystems,				
	<ul> <li>to develop process flows for</li> </ul>	r the fabrication o	f microstructures and			
Skills	<ul> <li>to develop process flows for the fabrication of microstructures and</li> <li>to apply them.</li> </ul>					
Personal Competence						
Social Competence	Students are able to prepare present and discuss the results			team work	as well as t	
Autonomy	None					
Workload in Hours	Independent Study Time 124, S	Study Time in Lec	ture 56			
Credit points	6					
	Compulsory Bonus For	m	Descriptio	n		



Course achievement	Yes None	Subject theoretical practical work	and durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebniise ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination			
Examination duration and scale	30 min		
Assignment for the Following Curricula	Elective Compulsory Electrical Engineering: Computational Science Elective Compulsory International Manager Compulsory Biomedical Engineering Biomedical Engineering Biomedical Engineering Compulsory Biomedical Engineering Compulsory	Specialisation Medical Techn and Engineering: Specialis ment and Engineering: S g: Specialisation Artificial Org g: Specialisation Implants and g: Specialisation Medical T	ation Systems Engineering and Robotics: pecialisation II. Mechatronics: Elective gans and Regenerative Medicine: Elective d Endoprostheses: Elective Compulsory echnology and Control Theory: Elective ent and Business Administration: Elective

Course L0724: Micros	Course L0724: Microsystems Technology		
Тур	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Lecturer	Prof. Hoc Khiem Trieu		
Language	EN		
Cycle	WiSe		
Content	<ul> <li>Introduction (historical view, scientific and economic relevance, scaling laws)</li> <li>Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive; angular rate sensor: operating principle and fabrication process)</li> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR,</li> </ul>		

	<ul> <li>fluxgate magnetometer)</li> <li>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)</li> <li>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, microreactor, lab-on-a-chip, microanalytics)</li> <li>MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration)</li> <li>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)</li> <li>System Integration (monolithic and hybrid integration, assembly and packageing, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>
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	Project-/problem-based Learning			
Hrs/wk	2			
СР	2			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Lecturer	Prof. Hoc Khiem Trieu			
Language	EN			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

ourses				
ïtle		Тур	Hrs/wk	СР
echnology Management	(L0849)	Project-/problem-based Learning	3	3
echnology Management	Seminar (L0850)	Project-/problem-based Learning	2	3
	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business man	agement		
Educational Objectives	After taking part successfully, students	s have reached the following lea	arning resu	lts
Professional Competence				
Knowledge	<ul> <li>International R&amp;D-Manageme</li> <li>Technology Timing Strategies         <ul> <li>Technology Strategies</li> <li>Technology Intelligenc</li> </ul> </li> <li>Technology Portfolio Manager         <ul> <li>Technology Portfolio Manager</li> <li>Technology Portfolio M</li> <li>Technology Acquisitior</li> <li>IP Management</li> </ul> </li> <li>Organizing Technology Developed on technology Portfolio &amp; technology Portfolio &amp; technology Portfolio &amp; technology Developed on technology Principal &amp; technology Funding &amp; techno</li></ul>	and Lifecycle Management (I/II) e and Planning nent lethodology n and Exploitation opment on & Management	)	
Skills	<ul> <li>Foster a strategic orientation t as Technology Management a</li> <li>Clarify activities of Technolog and exploitation)</li> <li>Strengthen essential communication</li> </ul>	al level inderstanding of important el ational, organizational and proce o problem-solving within the in and its importance for corporate y Management (e.g. technolog ication skills and a basic under ssues concerning Technology be discussed include: tools, relevant to the manager	lements o ess-related novation pr strategy y sourcing erstanding o -, Innovatio	f Technolog aspects) rocess as we , maintenanc of manageria on- and R&D
Personal Competence				
Social Competence	<ul><li>Interact within a team</li><li>Raise awareness for globabl is</li></ul>	ssues		

Autonomy	<ul> <li>Discuss recent research debates in the context of Technology and Innovation Management</li> <li>Develop presentation skills</li> <li>Discussion of international cases in R&amp;D-Management</li> </ul>			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

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

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

Courses										
Title					-	Тур		Hrs/wk	СР	
Control Systems Theory						_ecture Recitation Sectior	n (small)	2 2	4 2	
Module Responsible			rner				(21121)	_		
Admission										
Requirements Recommended										
Previous Knowledge	Introdu	ction to Co	ontrol Syst	ems						
Educational Objectives		king part s	successfull	ly, student	ts have rea	ached the follow	ving lea	rning resu	lts	
Professional Competence										
Knowledge		models; the trajectorie They carried to the tracking a They can They can They can They can Systems They can and how	hey can in es in state in explain in explain th explain o and disturb extend all explain th explain th explain th the identifi explain h	terpret the space the syster feedback e significa bserver-b ance rejection of the about e z-transfor state space ne experin cation pro	e system re m properti and state ince of a m ased state ction ove to mult orm and its se models mental ide blem can	amic systems a sponse to initia es controllabili estimation, resp ninimal realisati feedback and i-input multi-ou relationship wi and transfer fu ntification of AF be solved by so nodel can be c	Il states ity and pectivel on how it tput sys ith the L unction RX mod plving a	or externa observabi y can be us stems aplace Tra models of lels of dyn normal eq	al excita ility, and eed to a ansform f discre amic sy uation	tion a d the chiev te-tim vstems
Skills	•	versa They can They can They ca domain, a They can from expe They car	assess co design LC n carry of and decide identify tra erimental d	ntrollabilit QG controll ut a control which is ansfer fund lata t all thes	ty and obs lers for mu roller desig appropria ction mode e tasks us	on models into ervability and c ltivariable plant gn both in cor te for a given sa els and state sp sing standard Simulink)	onstruc ts ntinuous ampling ace mo	t minimal r s-time and rate dels of dyr	ealisatio discre namic s	ons te-tim ysterr
Personal										
Competence	Ctudon	ts can wo	rk in small	aroups or	n specific r	problems to arriv	ve at ioi	int solution	S.	
Social Competence						rovided source				oftwar
					•	when solving gi				
Autonomy	They c progres	an assess	s their kno	wledge ir	n weekly c	on-line tests an	d there	by control	their le	arnin

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	

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

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

Module M0867: F	Production Planning & Contr	ol and Digital Ente	erprise		
	<b>3</b>	<b>..</b>	•		
Courses					
Title		Тур	Hrs/wk	СР	
The Digital Enterprise (L0	932)	Lecture	2	2	
Production Planning and (	-	Lecture	2	2	
Production Planning and (	Control (L0930)	Recitation Section	(small) 1	1	
Exercise: The Digital Ente	erprise (L0933)	Recitation Section	(small) 1	1	
Module Responsible	Prof. Hermann Lödding				
Admission Requirements	None				
Recommended Previous Knowledge	Fundamentals of Production and Qual	ity Management			
Educational Objectives	After taking part successfully, students	have reached the following	ng learning resul	lts	
Professional Competence					
-	Students can explain the contents of th	e module in detail and ta	ke a critical posit	tion to them.	
Skills	Students are canable of choosing a		•		
Personal					
Competence					
-	Students can develop joint solutions ir	mixed teams and preser	nt them to others.		
Autonomy		· · · · · · · · · · · · · · · · · · ·			
	Independent Study Time 96, Study Tim	ne in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and scale	180 Minuten				
	International Management and Engi	neering: Specialisation	II. Product Deve	elopment and	
	Production: Elective Compulsory				
	Logistics, Infrastructure and Mobility	y: Specialisation Produc	ction and Logis	stics: Elective	
	Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective				
	Compulsory				
	Biomedical Engineering: Specialisatio	n Implants and Endopros	theses: Elective	Compulsory	
	Biomedical Engineering: Specialisati	on Medical Technology	and Control Th	eory: Elective	
Assignment for the	Compulsory	ation Monocomont on	d Dusiness (	Adamia in two tin or	
Following Curricula	I Riomodical Endingering. Specialication Management and Rijcingee Administration.				
	Product Development, Materials ar	d Production: Specialis	sation Product	Development:	
	Elective Compulsory			-	
	Product Development, Materials and Production: Specialisation Production: Compulsory Product Development, Materials and Production: Specialisation Materials: Elective				
	Product Development, Materials a Compulsory	and Production: Speci	alisation Mater	ials: Elective	
	Theoretical Mechanical Engineering:	Specialisation Product	Development an	d Production:	
	Elective Compulsory				
	Theoretical Mechanical Engineering:	Fechnical Complementary	/ Course: Elective	e Compulsory	

Course L0932: The Dig	gital Enterprise
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	<ul> <li>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.</li> <li>Content:</li> <li>Business Process Management and Data Modelling, Simulation</li> <li>Knowledge and Competence Management</li> <li>Process Management (PPC, Workflow Management)</li> <li>Computer Aided Planning (CAP) and NC-Programming</li> <li>Virtual Reality (VR) and Augmented Reality (AR)</li> <li>Computer Aided Quality Management (CAQ)</li> <li>Industry 4.0</li> </ul>
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: Produc	tion Planning and Control
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<ul> <li>Models of Production and Inventory Management</li> <li>Production Programme Planning and Lot Sizing</li> <li>Order and Capacity Scheduling</li> <li>Selected Strategies of PPC</li> <li>Manufacturing Control</li> <li>Production Controlling</li> <li>Supply Chain Management</li> </ul>
Literature	<ul> <li>Vorlesungsskript</li> <li>Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008</li> <li>Nyhuis, P.; Wiendahl, HP.: Logistische Kennlinien, Springer 2002</li> </ul>

Course L0930: Production Planning and Control			
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	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	Typ Recitation Section (small)			
Hrs/wk	1			
СР	1			
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Dr. Axel Friedewald			
Language	DE			
Cycle				
Content	See interlocking course			
Literature	Siehe korrespondierende Vorlesung See interlocking course			

Module M0921: E	Electronic Circuits for M	edical Applications		
Courses				
Title		Тур	Hrs/wk	СР
Electronic Circuits for Med Electronic Circuits for Med		Lecture Recitation Section (	2 (small) 1	3 2
Electronic Circuits for Med		Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical engin	neering		
Educational Objectives	Atter taking part successfully sti	udents have reached the following	ng learning resul	lts
Professional Competence				
Knowledge	<ul> <li>Students can explain the basic functionality of the information transfer by the central nervous system</li> <li>Students are able to explain the build-up of an action potential and its propagation along an axon</li> <li>Students can exemplify the communication between neurons and electronic devices</li> <li>Students can describe the special features of low-noise amplifiers for medical applications</li> <li>Students can explain the functions of prostheses, e. g. an artificial hand</li> <li>Students are able to discuss the potential and limitations of cochlea implants and artificial eyes</li> </ul>			
Skills	<ul> <li>Students can calculate the time dependent voltage behavior of an action potential</li> <li>Students can give scenarios for further improvement of low-noise and low-power signal acquisition.</li> <li>Students can develop the block diagrams of prosthetic systems</li> <li>Students can define the building blocks of electronic systems for an articifial eye.</li> </ul>			
Personal Competence				
Social Competence	<ul> <li>Students are trained to solve problems in the field of medical electronics in team together with experts with different professional background.</li> <li>Students are able to recognize their specific limitations, so that they can ask for assistance to the right time.</li> <li>Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary.</li> </ul>			
Autonomy	<ul> <li>actions for improvements</li> <li>Students can break dow work in a realistic way.</li> </ul>	alistically judge the status of the swhen necessary. In their work in appropriate work Complex data structures of bio	a packages and a	schedule thei



	<ul> <li>Students are able to act in a responsible manner in all cases and situations of experimental work.</li> </ul>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
	Compulsory Bonus Form Description			
Course achievement	Yes None Subject theoretical and practical work			
	No None Excercises			
Examination	Written exam			
Examination duration and scale	I 9() min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: 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: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

Course L0696: Electro	onic Circuits for Medical Applications			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Matthias Kuhl			
Language	EN			
Cycle	WiSe			
Content	<ul> <li>Market for medical instruments</li> <li>Membrane potential, action potential, sodium-potassium pump</li> <li>Information transfer by the central nervous system</li> <li>Interface tissue - electrode</li> <li>Amplifiers for medical applications, analog-digital converters</li> <li>Examples for electronic implants</li> <li>Artificial eye, cochlea implant</li> </ul>			
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		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

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

		<b>T</b>		
Title Continuum Mechanics (L1533)		<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Continuum Mechanics (L1533) Continuum Mechanics Exercise (L1534)		Recitation Section (small)		3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces an moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strai			
Educational Objectives	After taking part successfully, students have	reached the following lea	rning result	s
Professional Competence				
Knowledge	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
Skills	The students can set up balance laws an aspects, both in applied contexts as in resea		nation theo	ry to speci
Personal Competence				
Social Competence	The students are able to develop solutions, t develop ideas further.	o present them to special	ists in writte	n form and
Autonomy	The students are able to assess their independently and on their own identify mechanics and acquire the knowledge requi	and solve problems in		-
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
	Materials Science: Specialisation Modeling: Mechanical Engineering and Management: Mechatronics: Technical Complementary Co Biomedical Engineering: Specialisation Artif Compulsory	Specialisation Materials: ourse: Elective Compulso	ry erative Medi	cine: Electi



Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture Recitation Sectior	2 (cmall) 2	3
Material Modeling (L1536)		Recitation Section	n (small) 2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students h	ave reached the follow	ving learning resu	Its
Professional Competence				
Knowledge	The students can explain the fundament	als of multidimensiona	al consitutive mate	erial laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.			
Personal				
Competence				
Social Competence	The students are able to develop solu ideas further.	tions, to present then	n to specialists a	nd to develop
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L1535: Material Modeling	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>
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	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	<ul> <li>fundamentals of finite element methods</li> <li>fundamentals of material modeling</li> <li>introduction to numerical implementation of material laws</li> <li>overview of modelling of different classes of materials</li> <li>combination of macroscopic quantities to material microstructure</li> </ul>	
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: A	Advan	ced Fun	ctional N	Material	S			
Courses								
Title Typ Hrs/wk				<b>CP</b> 6				
Module Responsible	Prof. P	atrick Hube	r					
Admission Requirements	None							
Recommended Previous Knowledge		Basic knowledge in Materials Science, e.g. Materials Science I/II						
Educational Objectives	Atter ta	king part su	uccessfully,	students h	ave reached t	he following le	arning resu	lts
Professional								
Competence	1		h					
Knowledge	The students will be able to explain the properties of advanced materials along with the applications in technology, in particular metallic, ceramic, polymeric, semiconductor, moder composite materials (biomaterials) and nanomaterials.							
Skills	The students will be able to select material configurations according to the technical need and, if necessary, to design new materials considering architectural principles from the micro to the macroscale. The students will also gain an overview on modern materials science which enables them to select optimum materials combinations depending on the technica applications.							
Personal Competence								
Social Competence	The students are able to present solutions to specialists and to develop ideas further.			rther.				
	The students are able to							
Autonomy	gather new necessary expertise by their own.							
Workload in Hours	Indepe	ndent Stud	y Time 152,	Study Tim	e in Lecture 2	28		
Credit points	!							
Course achievement	None							
Examination	Presen	ntation						
Examination duration and scale	130 min							
Assignment for the Following Curricula	Materials Science: Core qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Electiv Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory							
	Theore	etical Mecha	-	-	•	blementary Cou Naterials Science		•

Course L1625: Advanc	ced Functional Materials
Тур	Seminar
Hrs/wk	2
СР	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ol> <li>Porous Solids - Preparation, Characterization and Functionalities</li> <li>Fluidics with nanoporous membranes</li> <li>Thermoplastic elastomers</li> <li>Optimization of polymer properties by nanoparticles</li> <li>Fiber composites in automotive</li> <li>Modeling of materials based on quantum mechanics</li> <li>Biomaterials</li> </ol>
Literature	Wird in der Veranstaltung bekannt gegeben

Courses				
<b>Title</b> Introduction to Biochemist	try and Molecular Biology (L0386)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	NIONO			
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ing learning resul	ts
Professional Competence				
Knowledge	<ul> <li>The students can</li> <li>describe basic biomolecules</li> <li>explain how genetic informa</li> <li>explain the connection betw</li> </ul>	tion is coded in the DNA;		
Skills	The students can <ul> <li>recognize the importance of</li> <li>describe selected molecular</li> <li>explain the relevance of these</li> </ul>	-diagnostic procedures;		ease;
Personal Competence				
Social Competence	The students can participate in disc	ussions in research and me	dicine on a techn	ical level.
Autonomy	The students can develop understa by themselves.	nding of topics from the co	urse, using techn	ical literature
Workload in Hours	Independent Study Time 62, Study	Fime in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following Curricula	General Engineering Science (Ge Engineering: Compulsory General Engineering Science (Ge Engineering, Focus Biomechanics: Electrical Engineering: Specialisatio General Engineering Science (Er Engineering, Focus Biomechanics: General Engineering Science (Er Engineering: Compulsory Mechanical Engineering: Specialisa Biomedical Engineering: Specialisa	erman program, 7 semest Compulsory on Medical Technology: Ele Iglish program, 7 semest Compulsory Iglish program, 7 semest ation Biomechanics: Compu	er): Specialisation ctive Compulsory er): Specialisation er): Specialisation	n Mechanica n Mechanica n Biomedica

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1333: B	BIO I: Implants and Fracture Healing		
Courses			
Title Implants and Fracture Hea	aling (L0376) Typ	<b>Hrs/wk</b> 2	<b>СР</b> 3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Fracture Haaling"	e attending	"Implants an
Educational Objectives	After taking part successfully, students have reached the following lea	arning resul	ts
Professional Competence			
Knowledge	The students can describe the different ways how bones heal, and t existence. The students can name different treatments for the spine and ho fracture morphologies.		
Skills	The students can determine the forces acting within the human situations under specific assumptions.	body unde	er quasi-stati
Personal Competence			
Social Competence	The students can, in groups, solve basic numerical modeling tas internal forces.	ks for the	calculation of
Autonomy	The students can, in groups, solve basic numerical modeling tas internal forces.	ks for the	calculation o
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
	Written exam		
Examination duration and scale	90 min		
	General Engineering Science (German program, 7 semester): Sp Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Sp Engineering: Compulsory General Engineering Science (English program, 7 semester): Sp Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Sp Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regene Compulsory Biomedical Engineering: Specialisation Implants and Endoprosthese Biomedical Engineering: Specialisation Medical Technology and Compulsory Biomedical Engineering: Specialisation Management and Business Compulsory Orientierungsstudium: Core qualification: Elective Compulsory	pecialisation pecialisation pecialisation erative Med s: Elective ( Control Th	n Biomedica n Mechanica n Biomedica icine: Electiv Compulsory eory: Electiv

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Typ       Lecture         Hrs.wk       2         OP       3         Workload in Hours       Independent Study Time 62, Study Time in Lecture 28         Lecturer       Prof. Michael Morlock         Language       DE         Cycle       WiSe         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, ligame         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         5.3.1 Screws         5.3.2 Plates         5.3.3 Naits         5.3.4 External fixation devices         5.3.5 Spine implants         6.0 New Implants         Cochran V.B.: Orthopådische Biomechanik	
CP         Workload in Hours         Independent Study Time 62, Study Time in Lecture 28         Lecturer         Prof. Michael Morlock         Language         DE       Cycle         Optics 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, ligame         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)         Content         5       Fracture Healing         5.1       Basics and biology of fracture repair         5.2       Clinical principals and terminology of fracture treatment         5.3.1       Screws         5.3.2       Plates         5.3.3       Naits         5.3.4       External fixation devices         5.3.5       Spine implants	
Workload in Hours         Independent Study Time 62, Study Time in Lecture 28           Lecturer         Prof. Michael Morlock           Language         DE           Cycle         WSe           Topics to be covered include:         1.           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, ligame           3.1         The spine in its entirety           3.2         Cervical spine           3.4         Lumbar spine           3.5         Injuries and diseases           4.         Pelvis (anatomy, biomechanics, fracture treatment)           Content         5         Fracture Healing           5.1         Basics and biology of fracture repair         5.2         Clinical principals and terminology 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	
Lecturer       Prof. Michael Morlock         Language       DE         Cycle       WiSe         Topics to be covered include:       1.         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, ligame         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)         Content       5         Fracture Healing         5.1       Biomechanics 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	
Language         DE           Cycle         WISe           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, ligame           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           5.3.1 Screws           5.3.2 Plates           5.3.3 Nails           5.3.4 External fixation devices           5.3.5 Spine implants           6.0 New Implants           Cochran V.B.: Orthopädische Biomechanik	
Cycle         WiSe           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, ligame           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)           Content           5 Fracture Healing           5.1 Basics and biology of fracture repair           5.2 Clinical principals and terminology 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	
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, ligand         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) <b>Content</b> 5         Fracture Healing         5.1       Basics and biology of fracture repair         5.2       Clinical principals and terminology 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         Cochran V.B.: Orthopädische Biomechanik	
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, ligame         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         5.3.1       Screws         5.3.2       Plates         5.3.3       Nails         5.3.4       External fixation devices         5.3.5       Spine implants         6.0       New Implants	
<ul> <li>3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligane</li> <li>3.1 The spine in its entirety</li> <li>3.2 Cervical spine</li> <li>3.3 Thoracic spine</li> <li>3.4 Lumbar spine</li> <li>3.5 Injuries and diseases</li> <li>4. Pelvis (anatomy, biomechanics, fracture treatment)</li> <li>Content</li> <li>5 Fracture Healing</li> <li>5.1 Basics and biology of fracture repair</li> <li>5.2 Clinical principals and terminology of fracture treatment</li> <li>5.3 Biomechanics of fracture treatment</li> <li>5.3.1 Screws</li> <li>5.3.2 Plates</li> <li>5.3.3 Nails</li> <li>5.3.4 External fixation devices</li> <li>5.3.5 Spine implants</li> <li>6.0 New Implants</li> <li>Cochran V.B.: Orthopädische Biomechanik</li> </ul>	
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Cochran V.B.: Orthopädische Biomechanik	
Mow V.C. Haves W.C. Basis Orthopsodia Dismoshanias	
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 M1334: E	BIO II: Biomaterials			
Courses				
<b>Title</b> Biomaterials (L0593)	TypHrs/wkCPLecture23			
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students can describe the materials of the human body and the materials being used i medical engineering, and their fields of use.			
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials			
Personal Competence				
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.			
Autonomy	The students are able to acquire information on their own. They can also judge the informatio with respect to its credibility.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula				

Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	

	<ul> <li>Topics to be covered include:</li> <li>1. Introduction (Importance, nomenclature, relations)</li> <li>2. Biological materials</li> <li>2.1 Basics (components, testing methods)</li> </ul>
	<ol> <li>Introduction (Importance, nomenclature, relations)</li> <li>Biological materials</li> <li>Basics (components, testing methods)</li> </ol>
	<ol> <li>2. Biological materials</li> <li>2.1 Basics (components, testing methods)</li> </ol>
	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
Content	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.
	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.
Literature	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, Spring 1996.	jer,

TUHH

		Тур	Hrs/wk	СР
			2	3 3
•				
None				
Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)				
After taking part success	fully, students have re	eached the following lea	rning resul	ts
The shade the	a ta alay iki ka shi k	and the second secon		finite - I
•				
	-	• • •	-	
equations.				
Students can work in sma	all groups on specific	problems to arrive at joi	nt solution:	з.
Independent Study Time	124, Study Time in L	ecture 56		
6				
Compulsory BonusNo20 %	<b>Form</b> Midterm	Descriptio	'n	
Written exam				
120 min				
	Mechanics I (Statics, Me Dynamics) Mathematics I, II, III (in pa After taking part successf The students possess at method and are able to method. The students are capat elements, assembling the equations. Students can work in sma The students are able develop own finite eleme scrutinized. Independent Study Time 6 Compulsory Bonus No 20 % Written exam 120 min	D3804)         Prof. Otto von Estorff         None         Mechanics I (Statics, Mechanics of Material Dynamics)         Mathematics I, II, III (in particular differential ed         After taking part successfully, students have read         The students possess an in-depth knowledge method and are able to give an overview method.         The students are capable to handle engine elements, assembling the corresponding syster equations.         Students can work in small groups on specific         The students are able to independently s develop own finite element routines. Problem scrutinized.         Independent Study Time 124, Study Time in L 6         Compulsory Bonus       Form         No       20 %         Midterm         120 min	D291)       Lecture         D804)       Recitation Section (large)         Prof. Otto von Estorff	2291)       Lecture       2         2804)       Recitation Section (large)       2         Prof. Otto von Estorff

	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
Assignment for the Following Curricula	Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core qualification: Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Compulsory

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

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

Module	M1342:	Poly	ymers

Title		Тур	Hrs/wk	СР		
Structure and Properties of Polymers (L0389)Lecture23						
Processing and design with polymers (L1892) Lecture 2 3						
Module Responsible	Dr. Hans Wittich					
Admission Requirements	None					
Recommended Previous Knowledge	Basics: chemistry / physics / mater	ial science				
Educational Objectives	After taking part successfully, stude	ents have reached the follow	ving learning resu	Its		
Professional Competence						
Competence	Students can use the knowledge c	f plastics and define the nec	essary testing an	d analysis.		
	They can explain the complex rela	tionships structure-property	relationship and			
Knowledge	the interactions of chemical stru contexts (e.g. sustainability, enviro		luding to explain	n neighborir		
	Students are capable of					
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.					
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.					
Personal Competence						
	Students can					
	- arrive at funded work results in h	eterogenius groups and doc	ument them.			
Social Competence	- provide appropriate feedback and handle feedback on their own performance constructively.					
	Students are able to					
	- assess their own strengths and w	eaknesses.				
Autonomy	- assess their own state of learning in specific terms and to define further work steps on this basis.					
	- assess possible consequences of their professional activity.					
Workload in Hours	Independent Study Time 124, Stud	ly Time in Lecture 56				
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and scale	180 min					
	Materials Science: Specialisation Biomedical Engineering: Specialis			sory		

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Electiv Compulsory					
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
Assignment for the	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective					
	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 Developmen Elective Compulsory					
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory					

Image: PropertiesImage: Properties	Course L0389: Structu	ire and Properties of Polymers
CP       3         Workload in Hours       Independent Study Time 62, Study Time in Lecture 28         Lecturer       Dr. Hans Wittich         Language       DE         Cycle       WiSe         - 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	Тур	Lecture
Workload in Hours         Independent Study Time 62, Study Time in Lecture 28           Lecturer         Dr. Hans Wittich           Language         DE           Cycle         WiSe           - 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           - Electrical modelling         - Theoretical modelling	Hrs/wk	2
Lecturer       Dr. Hans Wittich         Language       DE         Cycle       WiSe         - 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	СР	3
Language       DE         Cycle       WiSe         - 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	Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Cycle       WiSe         - 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	Lecturer	Dr. Hans Wittich
<ul> <li>Structure and properties of polymers</li> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology         <ul> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> </ul> </li> </ul>	Language	DE
<ul> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology         <ul> <li>Morphology</li> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> </ul> </li> </ul>	Cycle	WiSe
	Content	<ul> <li>Structure of macromolecules</li> <li>Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weihght distribution</li> <li>Morphology <ul> <li>amorph, crystalline, blends</li> <li>Properties</li> <li>Elasticity, plasticity, viscoelacity</li> <li>Thermal properties</li> <li>Electrical properties</li> <li>Theoretical modelling</li> </ul> </li> </ul>
Literature Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag	Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

Course L1892: Proces	Course L1892: Processing and design with polymers				
Тур	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Bodo Fiedler, Dr. Hans Wittich				
Language	DE/EN				
Cycle	WiSe				
Content Manufacturing of Polymers: General Properties; Calendering; Extrusion; In Thermoforming, Foaming; Joining Designing with Polymers: Materials Selection; Structural Design; Dimension					
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				

Madula M0622, E	ogonorativo Modio	ino			
	Regenerative Medic	line			
Courses					
<b>Title</b> Regenerative Medicine (L	0347)		<b>Typ</b> Seminar	Hrs/wk 2	<b>СР</b> 3
	ng - Regenerative Medicine (L	.1664)	Seminar	2	3
Module Responsible					
Admission Requirements	None				
Recommended Previous Knowledge					
Educational Objectives	After taking part successfu	ully, students have re	eached the followi	ng learning resul	lts
Professional Competence					
Knowledge	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells. The students can outline the actual concepts of Tissue Engineering and regenerative				
	<ul> <li>medicine and can explain the basic udnerlying principles of the discussed topics.</li> <li>After successful completion of the module students are</li> <li>able to use medical databases for acquirierung and presentation of relevant up-to-dat data independently</li> </ul>				
Skills	<ul> <li>able to present their work results in the form of presentations</li> <li>able to carry out basic cell culture methods and the corresponding analys independently</li> <li>able to analyse and evaluate current research topics for Tissue Engineering an regenerative medicine.</li> </ul>				
Personal					
Competence					
	Students are able to word discuss their results in the	-		ents to solve giv	ven tasks an
Social Competence	Students are able to reflect their work orally and discuss it with other students and teachers.				
Autonomy	After completion of this mo of approx. 2-4 persons inc			•	blem in team
	Independent Study Time 1	124, Study Time in L	ecture 56		
Credit points	I				
Course achievement	Compulsory BonusYes20 %	Form Written elaboration	Ausa	<b>cription</b> arbeitung zu Rir ocol for lecture se	
Examination	Presentation				
Examination duration and scale	Oral presentation + discus	ssion (30 min)			
anu suale	I				

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective
Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

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

		<b>_</b>			
-	Bioelectromagnetics	: Principles an	id Applications		
			_		
Title Bioelectromagnetics: Pring	ciples and Applications (L0371)	)	Typ Lecture	Hrs/wk 3	<b>CP</b> 5
-	ciples and Applications (L0373)		Recitation Section (small)	-	1
Module Responsible	Prof. Christian Schuster				
Admission Requirements					
Recommended Previous Knowledge					
Educational Objectives	After taking part successful	lly, students have re	ached the following lea	rning resul	ts
Professional	J				
Competence					
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.				
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.				
Personal Competence					
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).				
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 1	10, Study Time in Le	ecture 70		
Credit points		, , .,			
Course achievement	Compulsory Bonus	<b>Form</b> Presentation	Descriptio	n	

Examination	
Examination duration and scale	45 min
Assignment for the Following Curricula	Biomedical Engineering, Specialisation implants and Endoprostheses, Elective Complilisory

	ctromagnetics: Principles and Applications
Hrs/wk	
CP	
	 Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
	- 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
Content	- 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
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CR (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wile (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnet Fields", CRC (2006)
	FIEIUS, UNU (2000)

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

Module M0630: R	lobotics an	nd Naviga	ation in Medici	ne		
Courses						
Title	- Madiaira (LOOO			Тур	Hrs/wk	СР
Robotics and Navigation in Robotics and Navigation in				Lecture Project Seminar	2 2	3 2
Robotics and Navigation in	-			Recitation Section (small)	1	1
Module Responsible	Prof. Alexande	er Schlaefer				
Admission Requirements	None					
Recommended Previous Knowledge	<ul> <li>princip</li> </ul>		(algebra, analysis/ca amming, e.g., in Java kills	-		
Educational Objectives	After taking pa	rt successfu	lly, students have re	ached the following lea	rning resul	ts
Professional Competence						
Knowledge	systems and t	heir compoi safety and	nents in detail. Syst	cking systems in clinica tems can be evaluated its can assess typical sy	with respe	ect to collisi
Skills	The students medical applic		design and evalua	te navigation systems	and robot	ic systems
Personal Competence	The students	discuss th	e results of other	groups, provide help	oful feedb	ack and c
Social Competence				groups, provide holy		
Autonomy			their knowledge and ppropriate manner.	d document the results	of their w	ork. They c
Workload in Hours	Independent S	Study Time 1	10, Study Time in Lo	ecture 70		
Credit points	6					
Course achievement		<b>Bonus</b> 10 % 10 %	<b>Form</b> Written elaboration Presentation	Descriptio	'n	
Examination	Written exam					
Examination duration and scale	90 minutes					
	Electrical Engi International M Compulsory Mechatronics: Biomedical En Compulsory Biomedical En	neering: Sp Aanagemen Specialisati ngineering: S	ecialisation Medical t and Engineering: S on Intelligent Syster Specialisation Artific Specialisation Impla	Engineering: Elective ( Technology: Elective C Specialisation II. Electric ms and Robotics: Electiv ial Organs and Regene nts and Endoprostheses lical Technology and (	ompulsory cal Engine ve Compuls rative Med	; ering: Electi sory icine: Electi Compulsory

Assignment for the	Biomedical Engineering: Specialisation Management and Business Administration: Elective
Following Curricula	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 Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective
	Compulsory

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

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

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

## TUHH Hamburg University of Technology

Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical	Fechnology and Systems (L	_0342)	Lecture	2	3
Introduction into Medical Technology and Systems (L0343)			Project Seminar	2	2
Introduction into Medical	Fechnology and Systems (L	_1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlae	fer			
Admission Requirements	None				
	principles of math (alge	bra, analysis/calculus	3)		
Recommended	principles of stochastic	S			
Previous Knowledge	principles of programmi	ing, R/Matlab			
Educational Objectives	After taking part succes	sfully, students have r	reached the following lea	rning resul	ts
Professional					
Competence					
		• •	edical technology, inclu		
Knowledge			ation systems. They are	able to give	e an overviev
	of regulatory affairs and	i standards in medical	i technology.		
	The students are able	to evaluate systems	and medical devices i	n the cont	ext of clinica
Skills	applications.	,			
_					
Personal					
Competence					
Competence		a problem in medical	technology on a project	and dafina	tooko that ar
-	The students describe a	a problem in medical f	technology as a project,	and define	tasks that ar
-		a problem in medical t	technology as a project,	and define	tasks that ar
Social Competence	The students describe a solved in a joint effort. The students can refle	ct their knowledge ar	nd document the results		
Social Competence	The students describe a solved in a joint effort.	ct their knowledge ar	nd document the results		
Social Competence Autonomy	The students describe a solved in a joint effort. The students can refle	ct their knowledge ar appropriate manner.	nd document the results		
Social Competence Autonomy	The students describe a solved in a joint effort. The students can refle present the results in ar Independent Study Tim	ct their knowledge ar appropriate manner.	nd document the results		
Social Competence Autonomy Workload in Hours	The students describe a solved in a joint effort. The students can refle present the results in ar Independent Study Tim	ct their knowledge ar appropriate manner.	nd document the results	of their w	
Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 %	ct their knowledge ar n appropriate manner. e 110, Study Time in L Form Written elaboratio	nd document the results Lecture 70 Descriptic	of their w	
Social Competence Autonomy Workload in Hours Credit points	The students describe a solved in a joint effort. The students can refler present the results in ar Independent Study Tim 6 Compulsory Bonus	ct their knowledge ar n appropriate manner. e 110, Study Time in I Form	nd document the results Lecture 70 Descriptic	of their w	
Social Competence Autonomy Workload in Hours Credit points Course achievement	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 %	ct their knowledge ar n appropriate manner. e 110, Study Time in L Form Written elaboratio	nd document the results Lecture 70 Descriptic	of their w	
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam	ct their knowledge ar n appropriate manner. e 110, Study Time in L Form Written elaboratio	nd document the results Lecture 70 Descriptic	of their w	
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can refler present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes	ct their knowledge ar n appropriate manner. e 110, Study Time in I <b>Form</b> Written elaboration Presentation	nd document the results Lecture 70 Descriptic	of their wo	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination duration	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S	ct their knowledge ar n appropriate manner. e 110, Study Time in I Form Written elaboration Presentation Science (German pro	nd document the results Lecture 70 Description n ogram, 7 semester): Sp	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination duration	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering Sengineering: Compulsor	ct their knowledge ar appropriate manner. e 110, Study Time in I Form Written elaboration Presentation Science (German pro ory ecialisation Computer	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination duration	The students describe a solved in a joint effort. The students can reflee present the results in an independent Study Tim 6 Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes General Engineering Sengineering: Compulsor Species Spe	ct their knowledge ar n appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro ory ecialisation Computer Core qualification: Ele	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflee present the results in an independent Study Tim 6 Compulsory Bonus Yes 10 % Yes 10 % Written exam 90 minutes General Engineering Sengineering: Compulsor Species Spe	ct their knowledge ar n appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro pry scialisation Computer Core qualification: Ele Science (English pro	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can refler present the results in an Independent Study Tim 6 Compulsory Bonus Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering Sengineering: Compulsor Compulsor Science: Special Engineering Sengineering Sen	ct their knowledge ar appropriate manner. e 110, Study Time in I Form Written elaboration Presentation Science (German pro pry ecialisation Computer Core qualification: Ele Science (English pro pry	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering Engineering: Compulso Computational Science Science: Elective Comp	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro- bry ecialisation Computer Core qualification: Ele Science (English pro- bry e and Engineering: bulsory	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflee present the results in ar Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering Engineering: Compulso Computational Science Science: Elective Comp Computational Science	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro- bry ecialisation Computer Core qualification: Ele Science (English pro- bry e and Engineering: bulsory	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflee present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Computational Science	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro- bry ecialisation Computer Core qualification: Ele Science (English pro- pry e and Engineering: pulsory e and Engineering	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math :: Specialisation Comp	of their we	ork. They ca n Biomedica compulsory n Biomedica Engineerin nce: Electiv
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can reflec present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Computational Science	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro- bry ecialisation Computer Core qualification: Ele Science (English pro- pry e and Engineering: pulsory e and Engineering	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math	of their we	ork. They ca n Biomedica compulsory n Biomedica Engineerin nce: Electiv
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination duration and scale	The students describe a solved in a joint effort. The students can refler present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Compulsory Computational Science	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro Presentation Science (English pro Science (English pro Science (English pro Science (English pro pry e and Engineering: pulsory e and Engineering:	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math : Specialisation Comp Specialisation Enginee	of their we	ork. They ca
Social Competence Autonomy Workload in Hours Credit points Course achievement Examination Examination and scale	The students describe a solved in a joint effort. The students can refler present the results in an Independent Study Tim 6 <b>Compulsory Bonus</b> Yes 10 % Yes 10 % Written exam 90 minutes General Engineering S Engineering: Compulso Computer Science: Spe Electrical Engineering S Engineering: Compulso Computational Science Science: Elective Comp Computational Science Compulsory Computational Science	ct their knowledge ar appropriate manner. e 110, Study Time in L Form Written elaboration Presentation Science (German pro Presentation Science (English pro Science (English pro Science (English pro Science (English pro pry e and Engineering: pulsory e and Engineering:	nd document the results Lecture 70 Description n ogram, 7 semester): Sp and Software Engineerin ective Compulsory ogram, 7 semester): Sp Specialisation II. Math :: Specialisation Comp	of their we	ork. They ca

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

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

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

Co				
Courses Title Nonlinear Dynamics (L07	02)	Typ Integrated Lecture	Hrs/wk 4	<b>CP</b> 6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul><li>Calculus</li><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>			
Educational Objectives	After taking part successfully, students have	e reached the following	learning resu	lts
Professional Competence				
Knowledge	develop and research new terms and conc	epts.		
Skills	develop novel methods and procedures.	ds and procesures of I	Nonlinear Dy	namics and
Personal Competence				
-	Students can reach working results also in	aroups.		
Autonomy	Students are able to approach given resea		nd to identify	and follow u
Workload in Hours	Independent Study Time 124, Study Time in	n Lecture 56		
Credit points	6			
Course achievement	None			
	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elect Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compuls Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elect			

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

Fyp Lecture Practical Course Ind semiconductor of ched the following the techniques for Si- tion processes, pro- ces and integrated	learning resu and GaAs sub ocess flows a	ostrates,		
nd semiconductor of ched the following techniques for Sinition processes, processes, and integrated	2 devices learning resu and GaAs sub ocess flows a	2 Its		
nd semiconductor of ched the following n techniques for Si- tion processes, pro- ces and integrated	devices learning resu and GaAs sub ocess flows a	Its ostrates,		
ched the following n techniques for Si- tion processes, pro ces and integrated	learning resu and GaAs sub ocess flows a	ostrates,		
ched the following n techniques for Si- tion processes, pro ces and integrated	learning resu and GaAs sub ocess flows a	ostrates,		
ched the following n techniques for Si- tion processes, pro ces and integrated	learning resu and GaAs sub ocess flows a	ostrates,		
n techniques for Si tion processes, pro ces and integrated	and GaAs sub ocess flows a	ostrates,		
tion processes, processes and integrated	ocess flows a			
tion processes, processes and integrated	ocess flows a			
tion processes, processes and integrated	ocess flows a			
ces and integrated		nd the impac		
<ul> <li>to analyze the impact of process parameters on the processing results,</li> </ul>				
to select and to evaluate processes and				
of semiconductor de	evices.			
	in team work	as well as t		
ure 84				
	ir lab experiments nce. ture 84			

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 Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective
Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory

Course L0722: Semico	onductor Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process)</li> <li>Wafer fabrication (process flow, specification, SOI)</li> <li>Fabrication processes</li> <li>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)</li> <li>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)</li> <li>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)</li> <li>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, we chemical etching: isotropic and anisotropic, corner undercuting, compensation masks and etch stop techniques; dy etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> <li>Process integration (CMOS process, bipolar</li></ul>

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: Semico	ourse L0723: Semiconductor Technology				
Тур	Practical Course				
Hrs/wk	2				
СР	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				

Courses						
<b>Title</b> Humanoid Robotics (L066	3) <b>Typ</b> Seminar				<b>CP</b> 2	
Module Responsible	Patrick	Göttsch				
Admission Requirements	None					
Recommended Previous Knowledge		Introduction to control sys Control theory and desigr				
Educational Objectives	After taking part successfully, students have reached the following learning results					
Professional Competence						
Knowledge		Students can explain hum Students learn to apply ba	anoid robots. asic control concepts for differe	nt tasks in huma	noid robotics.	
Skills	<ul> <li>Students acquire knowledge about selected aspects of humanoid robotics, based or specified literature</li> <li>Students generalize developed results and present them to the participants</li> <li>Students practice to prepare and give a presentation</li> </ul>					
Personal Competence						
Social Competence	•	them	developing solutions in interd		•	
Autonomy	<ul> <li>Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution</li> <li>Students familiarize themselves with a scientific field, are able of introduce it and follo presentations of other students, such that a scientific discussion develops</li> </ul>					
Workload in Hours	Indepe	ndent Study Time 32, Stud	ly Time in Lecture 28			
Credit points	2					
Course achievement	None					
Examination	Preser	tation				
Examination duration and scale	30 min					
Assignment for the	Mecha Biome Compu Biome	tronics: Specialisation Sys dical Engineering: Special Ilsory dical Engineering: Special dical Engineering: Special	Iligent Systems and Robotics: tem Design: Elective Compuls isation Artificial Organs and Re isation Implants and Endopros Ilisation Medical Technology	ory egenerative Med theses: Elective	icine: Electiv	

Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses				
<b>Title</b> Linear and Nonlinear Syst	tem Identification (L0660)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>Discrete-time systems</li> </ul>	decomposition		
Educational Objectives	After taking part successfully, students	s have reached the follow	ving learning resu	lts
Professional Competence				
Knowledge	<ul> <li>Students can explain the general framework of the prediction error method and application to a variety of linear and nonlinear model structures</li> <li>They can explain how multilayer perceptron networks are used to model nonline dynamics</li> <li>They can explain how an approximate predictive control scheme can be based on neural network models</li> <li>They can explain the idea of subspace identification and its relation to Kalma realisation theory</li> </ul>			
Skills	<ul> <li>Students are capable of app identification of linear and non</li> <li>They are capable of impleme neural network model</li> <li>They are capable of applying linear models for dynamic syst</li> <li>They can do the above using Identification Toolbox)</li> </ul>	linear models for dynam nting a nonlinear predic subspace algorithms to t tems	ic systems tive control schem he experimental id	ne based on dentification
Personal Competence				
Social Competence			-	
Autonomy	Students are able to find required in software documentation) and use it to		ovided (lecture no	nes, iiteratur
Workload in Hours	Independent Study Time 62, Study Tir	me in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	(30) min			
Course achievement Examination Examination duration	None Oral exam 30 min			-

	Mechatronics: Specialisation System Design: Elective Compulsory
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective
Following Curricula	Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses						
<b>Title</b> Optimal and Robust Cont	rol (1.06)	59)	<b>Typ</b> Lecture		Hrs/wk 2	<b>СР</b> 3
Optimal and Robust Cont			Recitation Section	(small)		3
Module Responsible	Prof. H	Herbert Werner				
Admission Requirements	NICNO					
Recommended Previous Knowledge	•	<ul> <li>Classical control (frequency response, root locus)</li> <li>State space methods</li> <li>Linear algebra, singular value decomposition</li> </ul>				
Educational Objectives	Atter to	aking part successfully, stu	dents have reached the follow	ng lea	rning resul	ts
Professional Competence						
Knowledge	<ul> <li>Students can explain the significance of the matrix Riccati equation for the solution LQ problems.</li> <li>They can explain the duality between optimal state feedback and optimal state estimation.</li> <li>They can explain how the H2 and H-infinity norms are used to represent stability a performance constraints.</li> <li>They can explain how an LQG design problem can be formulated as special case an H2 design problem.</li> <li>They can explain how model uncertainty can be represented in a way that lends its to robust controller design</li> <li>They can explain how - based on the small gain theorem - a robust controller controller controller for an uncertain plant.</li> <li>They understand how analysis and synthesis conditions on feedback loops can represented as linear matrix inequalities.</li> </ul>					
Skills	<ul> <li>Students are capable of designing and tuning LQG controllers for multivariable pl models.</li> <li>They are capable of representing a H2 or H-infinity design problem in the form of generalized plant, and of using standard software tools for solving it.</li> <li>They are capable of translating time and frequency domain specifications for con loops into constraints on closed-loop sensitivity functions, and of carrying out a mix sensitivity design.</li> <li>They are capable of constructing an LFT uncertainty model for an uncertain syste and of designing a mixed-objective robust controller.</li> <li>They are capable of formulating analysis and synthesis conditions as linear ma inequalities (LMI), and of using standard LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust con toolbox).</li> </ul>					
Personal Competence						
Social Competence		-	os on specific problems to arriv			
Autonomy	Students are able to find required information in sources provided (lecture notes, literatus software documentation) and use it to solve given problems.					

Workload in Hours
Credit points
Course achievement
Examination
Examination duration and scale
Assignment for the Following Curricula

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

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

Courses						
<b>Title</b> Marketing of Innovations (	(L2009)		<b>Typ</b> Lecture		<b>Hrs∕wk</b> 4	<b>CP</b> 4
PBL Marketing of Innovati	ons (L08	862)	Project-/problem-b Learning	ased	1	2
Module Responsible	Prof. C	Christian Lüthje				
Admission Requirements	None					
Recommended Previous Knowledge	•	Module International Business Basic understanding of busine theory, project management, in Bachelor-level Marketing Kno Strategies, Basics of Buying B Unerstanding the differences b Understanding of the important Good English proficiency; pres	ss administration principl International business) wledge (Marketing Instru ehavior) peweetn B2B and B2C ma ce of managing innovatio	ments urketir	s, Market ar ng	nd Competi
Educational Objectives	After ta	aking part successfully, students	have reached the followi	ng lea	arning resul	ts
Professional Competence						
Knowledge	• • • • • • • • • • • • • • • • • • • •	nts will have gained a deep und Specific characteristics in the r Approaches for analyzing t development The gathering of information a Concepts and approaches to service development processe Approaches and tools for en- products and innovative servic Marketing mix elements that challenges of innovative product Pricing methods for new product The organization of complex s Communication concepts and	narketing of innovative po he current market situation oout future customer need integrate lead users and suring customer-orientation es take into consideration icts and services cts and services ales forces and personal instruments for new produ	ation ds and d their on in the sp selling	and the the the the the develop the develop pecific requ	future mark onts oproduct a pment of ne
Skills	• • •	on the acquired knowledge stu Design and to evaluate decision Analyze markets by applying r Conduct forecasts and develor Translate customer needs i successfully apply advanced development Use adequate methods to fost Choose suitable pricing strate Make strategic sales decision channels) Apply methods of sales force r	ons regarding marketing a narket and technology po o compelling scenarios as nto concepts, prototypes methods for customer- er efficient diffusion of inn gies and communication a ns for products and se	rtfolios a ba and orient ovativ activiti rvices	s sis for strate l marketabl ted products e products es for innov s (i.e. selec	egic plannin le offers a t and servi and service vations

Social Competence	<ul> <li>have fruitful discussions and exchange arguments</li> <li>develop original results in a group</li> <li>present results in a clear and concise way</li> <li>carry out respectful team work</li> </ul>			
Autonomy	<ul> <li>The students will be able to</li> <li>Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields.</li> <li>Consider proposed business actions in the field of marketing and reflect on them.</li> </ul>			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and scale	Written elaboration, excercises, presentation, oral participation			
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective			

TUHH

urse L2009: Market	ing of Innovations
	Lecture
Hrs/wk	4
СР	4
	Independent Study Time 64, Study Time in Lecture 56
	Prof. Christian Lüthje
Language	
Cycle	
	<ul> <li>Introduction</li> <li>Innovation and service marketing (importance of innovative products and service model, objectives and examples of innovation marketing, characteristics of service challenges of service marketing)</li> </ul>
	II. Methods and approaches of strategic marketing planning
	<ul> <li>patterns of industrial development, patent and technology portfolios</li> </ul>
	III. Strategic foresight and scenario analysis
	<ul> <li>objectives and challenges of strategic foresight, scenario analysis, Delphi method</li> </ul>
	IV. User innovations
Content	<ul> <li>Role of users in the innovation process, user communities, user innovation toolkin lead users analysis</li> </ul>
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products a innovations, third edition, Pearson education. ISBN-10: 1292040335 . Chapter 6 (188-21) Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw H Boston et al., 2008
Literature	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firr to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 <sup>th</sup> edition, Boston et a McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

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

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering -	Fundamentals (L0841)	Lecture	2	3
Bioprocess Engineering- I	. ,	Recitation Section (large)	2	1
Bioprocess Engineering -	Fundamental Practical Course (L0843)	Practical Course	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	nong module "organic chemistry" mo	odule "fundamentals for process	engineerir	ıg"
Educational Objectives	After taking part successfully, students	s have reached the following lea	rning resul	ts
Professional				
Competence				
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able t classify different types of kinetics for enzymes and microorganisms, as well as to differentiat different types of inhibition. The parameters of stoichiometry and rheology can be named an mass transport processes in bioreactors can be explained. The students are capable t explain fundamental bioprocess management, sterilization technology and downstrear processing in detail.			
Skills	<ul> <li>describe different kinetic approaches for growth and substrate-uptake and to calcula the corresponding parameters</li> <li>predict qualitatively the influence of energy generation, regeneration of rede equivalents and growth inhibition on the fermentation process</li> <li>analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic fluequations</li> <li>distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply the to current biotechnical problem</li> <li>propose solutions to complicated biotechnological problems and to deduce the corresponding models</li> <li>to explore new knowledge resources and to apply the newly gained contents</li> <li>identify scientific problems with concrete industrial use and to formulate solutions.</li> </ul>			
Personal Competence				
Social Competence	After completion of this module participants should be able to debate technical questions small teams to enhance the ability to take position to their own opinions and increase the capacity for teamwork in engineering and scientific environments.			
Autonomy	After completion of this module participants will be able to solve a technical problem in a tean independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Tir	me in Lecture 84		

	practical work
	Written exam
Examination duration and scale	90 min
•	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, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: 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 Process Engineering: Core qualification: Compulsory

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

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

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

Module M1143: N	lechanical Design Me	thodology		
Courses				
<b>Title</b> Mechanical Design Metho Mechanical Design Metho		<b>Typ</b> Lecture Recitation Sec	Hrs/wk 3 stion (small) 1	<b>CP</b> 4 2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	students have reached the fol	lowing learning resul	ts
Professional Competence				
Knowledge	Science-based working on product design considering targeted application of specific produ design techniques			pecific produc
Skills	Creative handling of processes used for scientific preparation and formulation of comple product design problems / Application of various product design techniques followin theoretical aspects.			
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124	, Study Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	130 min			
Assignment for the Following Curricula	I BIOMARICAL ENRINGATING' SPACIALICATION MARICAL LACHNOLOGY AND L'ONTROL LNAORY' ELACTI			icine: Elective Compulsory eory: Elective ation: Elective

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

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

ICD Is introduction to Anotomy			
IED I: Introduction to Anatomy			
.0384)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Prof. Udo Schumacher			
None			
None			
After taking part successfully, students ha	ve reached the follow	ing learning resul	lts
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.			
The students can recognize the relationship between given anatomical facts and th development of some common diseases; they can explain the relevance of structures an their functions in the context of widespread diseases.			
The students can participate in current discussions in biomedical research and medicine on professional level.			
The students are able to access anatomical knowledge by themselves, can participate i conversations on the topic and acquire the relevant knowledge themselves.			
Independent Study Time 62, Study Time in Lecture 28			
3			
None			
Written exam			
90 minutes			
General Engineering Science (German program, 7 semester): Specialisation Biomedica Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedica 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			
	0384) Prof. Udo Schumacher None None After taking part successfully, students hav The students can describe basal strue musculoskeletal system. The students can recognize the relati development of some common diseases their functions in the context of widespreae The students are able to access anator conversations on the topic and acquire the Independent Study Time 62, Study Time in 3 None Written exam 90 minutes General Engineering Science (German Engineering; Compulsory General Engineering: Specialisation Mer General Engineering Science (English Engineering; Compulsory Mechanical Engineering: Specialisation E Biomedical Engineering: Specialisation I Compulsory Biomedical Engineering:	Lecture           Prof. Udo Schumacher           None           None           After taking part successfully, students have reached the follow           The students can describe basal structures and functions musculoskeletal system.           The students can describe the basic macroscopy and microsco           The students can recognize the relationship between giv development of some common diseases; they can explain the their functions in the context of widespread diseases.           The students are able to access anatomical knowledge by conversations on the topic and acquire the relevant knowledge by conversations on the topic and acquire the relevant knowledge by mone           Written exam         90 minutes           General Engineering Science (German program, 7 semest Engineering: Compulsory         Semestation Medical Technology: Ele General Engineering Science (English program, 7 semest Engineering; Specialisation Medical Technology: Ele General Engineering: Specialisation Medical Technology: Ele General Engineering: Specialisation Biomechanics: Compulsory           General Engineering Science (English program, 7 semest Engineering; Focus Biomechanics: Compulsory           General Engineering Science (English program, 7 semest Engineering: Specialisation Medical Technology: Ele General Engineering: Specialisation Medical Technology           Biomedical Engineering: Specialisation Biomechanics: Compulsory           General Engineering: Specialisation Biomechanics: Compulsory           General Engineering: Specialisation Biomechanics: Compulsory	Typ         Hrs/wk           0384)         Lecture         2           Prof. Udo Schumacher         None

Тур	Lecture		
Hrs/wk			
CP			
		udy Time 62, Study Time in Lecture 28	
	Prof. Tobias La	· · ·	
Language			
Cycle			
	General Anato	my	
	1 <sup>st</sup> week:	The Eucaryote Cell	
	2 <sup>nd</sup> week:	The Tissues	
	3 <sup>rd</sup> week:	Cell Cycle, Basics in Development	
	4 <sup>th</sup> week:	Musculoskeletal System	
	5 <sup>th</sup> week:	Cardiovascular System	
	6 <sup>th</sup> week:	Respiratory System	
Content	7 <sup>th</sup> week:	Genito-urinary System	
Contoni	8 <sup>th</sup> week:	Immune system	
	9 <sup>th</sup> week:	Digestive System I	
	10 <sup>th</sup> week:	Digestive System II	
	11 <sup>th</sup> week:	Endocrine System	
	12 <sup>th</sup> week:	Nervous System	
	13 <sup>th</sup> week:	Exam	
Literature	Adolf Faller/Mi Stuttgart, 2012	chael Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verl	

Courses				
Fitle ntroduction to Physiology	(L0385)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students ha	ve reached the follow	ring learning resul	ts
Professional Competence	The students can			
Knowledge	<ul> <li>describe the basics of the energy metabolism:</li> </ul>			
Skills	The students can describe the effects or processing of information, development or technical systems.		· ·	
Personal Competence				
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical a metrological.			
Autonomy	The students can derive answers to questions arising in the course and other physiologic areas, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time i	n Lecture 28		
Credit points	3			
Course achievement	None			
	Written exam			
Examination duration and scale	60 minutes			
Assignment for the Following Curricula	Maahanjaal Enginaaring, Spaajaljaatian Diamaahanjaa, Campulaary			n Mechanio n Mechanio n Biomedio

Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Courses				
Fitle ntroduction to Radiology a	and Radiation Therapy (L0383)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, studer	nts have reached the follow	wing learning resu	lts
Professional Competence				
	<b>Therapy</b> The students can distinguish differe in radiation therapy.	nt types of currently used (	equipment with res	spect to its u
	The students can explain treatme contexts (e.g. surgery, internal medi	•	ion therapy in in	terdisciplina
	The students can describe the pa follow-up care.	tients' passage from the	eir initial admittan	ce through
	Diagnostics			
Knowledge	The students can illustrate the technical base concepts of projection radiography, includin angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).			
	The students can explain the diagn well as the technical basis for those	•	ic use of imaging t	echniques,
	The students can choose the right tr and needs.	eatment method dependir	ng on the patient's	clinical histo
	The student can explain the influence	e of technical errors on th	e imaging techniqi	ues.
	The student can draw the right con error protocol.	clusions based on the im	nages' diagnostic f	indings or t
	<b>Therapy</b> The students can distinguish curativ that conclusion.	ve and palliative situations	s and motivate why	y they came
	The students can develop adequate aspects.	e therapy concepts and re	elate it to the radia	tion biologi
	The students can use the therapeuti	c principle (effects vs adve	erse effects)	
Skills	The students can distinguish differe on the situation (location of the t (irradiation planning).			•
	The student can assess what an inc up treatment, sports, social help gro			
	Diagnostics			
	The students can suggest solutions	s for repairs of imaging in	strumentation afte	r having do

	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.		
Personal Competence			
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.		
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine. The students are able to access anatomical knowledge by themselves, can participate competently 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			
Course achievement	None		
	Written exam		
Examination duration and scale	90 minutes		
	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, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0383: Introdu	ction to Radiology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments

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Literature	<ul> <li>"Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999</li> <li>"Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr –</li> <li>4. Auflage - Verlag Urban &amp; Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1</li> <li>"Strahlentherapie und Onkologie für MTA-R" von R. Sauer – 5. Auflage 2003 - Verlag Urban &amp; Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6</li> <li>"Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus 8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8</li> <li>"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</li> <li>"Praxismanual Strahlentherapie" von Stöver / Feyer – 1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000</li> </ul>



Module M1332: E	BIO I: Experimental Methods	in Biomechanics		
Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in I	Biomechanics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	"Experimentalla Mathemalen"	n "Implantate und Fral	kturheilung" bef	ore attendin
Educational Objectives	Atter taking part successfully students	have reached the followi	ng learning resul	lts
Professional Competence				
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under given fracture morphologies. The students can describe different measurement techniques for forces and movements, and choose the adequate technique for a given task.			
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.			
Personal Competence				
Social Competence	The students can, in groups, solve bas	sic experimental tasks.		
Autonomy	The students can, in groups, solve bas	sic experimental tasks.		
Workload in Hours	Independent Study Time 62, Study Tin	ne in Lecture 28		
Credit points	l			
Course achievement				
Examination Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (Germ Engineering, Focus Biomechanics: Co General Engineering Science (Germ Engineering: Compulsory General Engineering Science (Engl Engineering, Focus Biomechanics: Co General Engineering Science (Engl Engineering: Compulsory Mechanical Engineering: Specialisatio	ompulsory nan program, 7 semester ish program, 7 semester ompulsory ish program, 7 semester on Biomechanics: Compu on Artificial Organs and R n Implants and Endopros on Medical Technology on Management and Bus	er): Specialisatio er): Specialisatio er): Specialisatio lsory egenerative Med and Control Th siness Administra	n Biomedica n Mechanica n Biomedica licine: Electiv Compulsory eory: Electiv ation: Electiv

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

Module M1335: E	BIO II: Artificial Joint Re	placement		
Courses				
Title Artificial Joint Replacemen	nt (L1306)	<b>Typ</b> Lecture	Hrs/wk 2	<b>СР</b> 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic	and surgical techniques is recon	nmended.	
Educational Objectives	After taking part successfully, s	tudents have reached the following	ng learning resul	ts
Professional Competence				
Knowledge	The students can name the diff	erent kinds of artificial limbs.		
Skills	The students can explain t endoprotheses.	the advantages and disadvar	ntages of differ	ent kinds of
Personal Competence				
Social Competence	The students are able to discuss issues related to endoprothese with student mates and the teachers.			
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.			
Workload in Hours	Independent Study Time 62, St	udy Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	un min			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Dientierungsstudium: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L1306: Artifici	al 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	
	Inhalt (deutsch)
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenkerssatzes)
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)
	<ol> <li>DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite Evolution der Implantate)</li> </ol>
Content	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)
	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, Nev York 1994
Literature	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

Module M0845: F	eedback Control in Medic	al Technology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medi	cal Technology (L0664)	Lecture	2	3
Module Responsible	l			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Control, Basics in Physiol	ogy		
Educational Objectives	After taking part successfully, studer	nts have reached the follow	ing learning resul	ts
Professional Competence				
	The lecture will introduce into the fa point of view. Fundamentals in hun in control theory.	0	•••	• •
Knowledge	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system fo example in for anesthesia control.			
	The handling of PID controllers a controller or neural networks will be be discussed.		•	
Skills	Application of modeling, identification	on, control technology in the	e field of medical t	echnology.
Personal				
Competence		·~		
Social Competence	Students can develop solutions to s	pecific problems in small gr	oups and presen	t their results
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.			
Workload in Hours	Independent Study Time 62, Study	Time in Lecture 28		
Credit points				
Course achievement				
Examination	l			
Examination duration and scale	20 min			
Assignment for the Following Curricula	Biomodical Endingering. Specialies	tion Control and Power S ation Implants and Endopros ation Artificial Organs and F	Systems Enginee stheses: Elective ( Regenerative Med	ering: Elective Compulsory icine: Elective
	Biomedical Engineering: Specialisa	tion Medical Technology a	nd Control Theory	: Compulsor

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

## Module M0832: Advanced Topics in Control

Title		Тур	Hrs/wk	СР
Advanced Topics in Contr	ol (L0661)	Lecture	2	3
Advanced Topics in Contr		Recitation Section	n (small) 2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-sen	nsitivity design, linear matri	x inequalities	
Educational Objectives	After taking part successfully, studer	nts have reached the follov	ving learning resu	lts
Professional Competence				
	<ul> <li>Students can explain the scheduling approach</li> <li>They can explain the represystems</li> <li>They can explain how stab formulated as LMI conditions</li> <li>They can explain how grisynthesis problems for LPV s</li> <li>They are familiar with polytor the basic synthesis technique</li> </ul>	esentation of nonlinear systems ility and performance con s idding techniques can be systems opic and LFT representatio	stems in the form ditions for LPV sy e used to solve ns of LPV system	of quasi-Ll ystems can analysis a s and some
Knowledge	<ul> <li>Students can explain how communication topology of r</li> <li>They can explain the conver</li> <li>They can explain analysis involving either LTI or LPV a</li> </ul>	multiagent systems gence properties of first or s and synthesis condition	der consensus pr	otocols
	<ul> <li>Students can explain the st systems that are discretized</li> <li>They can explain (in outlin distributed systems and the a</li> </ul>	according to an actuator/sone) the extension of the	ensor array bounded real le	emma to su
	<ul> <li>Students are capable of cor mixed-sensitivity design or polytopic, LFT or general LP</li> <li>They are able to use standa tasks</li> </ul>	f gain-scheduled control V models	lers; they can o	do this usi
Skills	<ul> <li>Students are able to design either LTI or LPV dynamics,</li> </ul>			of agents w
	<ul> <li>Students are able to design using the Matlab MD-toolbox</li> </ul>		patially interconne	ected systen

Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

Course L0661: Advance	ced Topics in Control	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	<ul> <li>Linear Parameter-Varying (LPV) Gain Scheduling         <ul> <li>Linearizing gain scheduling, hidden coupling</li> <li>Jacobian linearization vs. quasi-LPV models</li> <li>Stability and induced L2 norm of LPV systems</li> <li>Synthesis of LPV controllers based on the two-sided projection lemma</li> <li>Simplifications: controller synthesis for polytopic and LFT models</li> <li>Experimental identification of LPV models</li> <li>Controller synthesis based on input/output models</li> <li>Controller synthesis based on input/output models</li> <li>Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator</li> </ul> </li> <li>Control of Multi-Agent Systems         <ul> <li>Communication graphs</li> <li>Spectral properties of the graph Laplacian</li> <li>First and second order consensus protocols</li> <li>Formation control, stability and performance</li> <li>LPV models for agents subject to nonholonomic constraints</li> <li>Application: formation control for a team of quadrotor helicopters</li> </ul> </li> <li>Control of Spatially Interconnected Systems         <ul> <li>Multidimensional signals, I2 and L2 signal norm</li> <li>Multidimensional systems in Roesser state space form</li> <li>Extension of real-bounded lemma to spatially interconnected systems</li> <li>LMI-based synthesis of distributed controllers</li> <li>Spatial LPV control of spatially varying systems</li> <li>Applications: control of temperature profiles, vibration damping for an actuated beam</li> </ul> </li> </ul>	
Literature	<ul> <li>Werner, H., Lecture Notes "Advanced Topics in Control"</li> <li>Selection of relevant research papers made available as pdf documents via StudIP</li> </ul>	

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

## Thesis

Module M-002: M			
Courses			
Title	Тур	Hrs/wk	СР
Module Responsible	Professoren der TUHH		
Admission Requirements	<ul> <li>According to General Regulations §21 (1): At least 60 credit points have to be achieved in study programme. The examination board decides on exceptions.</li> </ul>		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	<ul> <li>The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues.</li> <li>The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them.</li> <li>The students can place a research task in their subject area in its context and describe and critically assess the state of research.</li> </ul>		
Skills	<ul> <li>The students are able:</li> <li>To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.</li> <li>To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way.</li> <li>To develop new scientific findings in their subject area and subject them to a critical assessment.</li> </ul>		
Personal Competence			
Social Competence	<ul> <li>Students can</li> <li>Both in writing and orally outline a scientific issue for an expert audience accurate understandably and in a structured way.</li> <li>Deal with issues compotently in an expert discussion and answer them in a many structure.</li> </ul>		in a manne
	<ul> <li>Students are able:</li> <li>To structure a project of their own in work packages and to work them off accordingly.</li> </ul>		
Autonomy	<ul> <li>To work their way in depth into a largely information required for them to do so.</li> </ul>	unknown subject and to	o access th

	• To apply the techniques of scientific work comprehensively in research of their own.		
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0		
Credit points 30			
Course achievement	None		
Examination	Thesis		
Examination duration and scale	According to General Regulations		
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory 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 Global Innovation Management: Thesis: Compulsory Information and Communication Systems: 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 Materials Science: Thesis: Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Ship and Offshore Technology: Thesis: Compulsory Ship and Offshore Technology: Thesis: Compulsory Process Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory		

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