

# **Module Manual**

Master of Science (M.Sc.)

# **Biomedical Engineering**

Cohort: Winter Term 2021

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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: Busin	ess & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	<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	Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

# Courses

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

# Module M0524: Non-technical Courses for Master Dagmar Richter **Module Responsible Admission Requirements** None **Recommended Previous** Knowledge

### **Professional Competence**

#### Knowledge The Nontechnical Academic Programms (NTA)

Educational Objectives After taking part successfully, students have reached the following learning results

imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its teaching architecture, in its teaching and learning arrangements, in teaching areas and by means of teaching offerings in which students can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary 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 of TUHH degree courses.

The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".

The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.

#### Teaching and Learning Arrangements

provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.

# Fields of Teaching

are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.

The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goaloriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.

# The Competence Level

of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These 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 team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.

# Specialized Competence (Knowledge)

# Students can

- · explain specialized areas in context of the relevant non-technical disciplines,
- outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area.
- different specialist disciplines relate to their own discipline and differentiate it as well as make connections,
- sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,
- Can communicate in a foreign language in a manner appropriate to the subject.

# Skills Professional Competence (Skills)

# In selected sub-areas students can

- · apply basic and specific methods of the said scientific disciplines,
- · aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist
- · to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner,
- justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

Davisanal Commetence	
Personal Competence	Personal Competences (Social Skills)
Social competence	Tersonal competences (Social Skins)
	<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> <li>to explain nontechnical items to auditorium with technical background knowledge.</li> </ul>
Autonomy	Personal Competences (Self-reliance) Students are able in selected areas
	to reflect on their own profession and professionalism in the context of real-life fields of application
	<ul> <li>to organize themselves and their own learning processes</li> <li>to reflect and decide questions in front of a broad education background</li> </ul>
	to communicate a nontechnical item in a competent way in writen form or verbaly
	• to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

# Courses

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

Module M1173: Appli	ed Statistics					
Courses						
Title				Тур	Hrs/wk	СР
Applied Statistics (L1584)			1	Lecture	2	3
Applied Statistics (L1586)			1	Project-/problem-based Learning	2	2
Applied Statistics (L1585)				Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock					
<b>Admission Requirements</b>	None					
Recommended Previous	Basic knowledge of statist	ical methods				
Knowledge						
Educational Objectives	After taking part successf	ully, students have rea	ched the following	g learning results		
Professional Competence						
Knowledge	Students can explain the	statistical methods and	d the conditions of	f 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 1	110, Study Time in Lec	ture 70			
Credit points	6					
Course achievement	Compulsory Bonus For	m	Description			
	Yes None Wr	itten elaboration				
Examination	Written exam					
Examination duration and	90 minutes, 28 questions					
scale						
Assignment for the	Mechanical Engineering a	nd Management: Spec	ialisation Manage	ment: Elective Compulsory		
Following Curricula	Mechatronics: Specialisati	on System Design: Ele	ctive Compulsory			
	Mechatronics: Specialisati	on Intelligent Systems	and Robotics: Ele	ctive Compulsory		
	Biomedical Engineering: C	ore Qualification: Com	pulsory			
	Product Development, Ma	terials and Production:	: Core Qualification	n: Elective Compulsory		
	Theoretical Mechanical En	gineering: Specialisati	on Bio- and Medic	al Technology: Elective Compu	Isory	

Course L1584: Applied Statis	stics		
Тур	ecture		
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	The goal is to introduce students to the basic statistical methods and their application to simple problems. The topics include:		
	Chi square test		
	Simple regression and correlation		
	Multiple regression and correlation		
	One way analysis of variance		
	Two way analysis of variance		
	Discriminant analysis		
	Analysis of categorial data		
	Chossing the appropriate statistical method		
	Determining critical sample sizes		
Literature	Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper		
	University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University,		
	Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6		

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

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

_	
Courses	
Title	Typ Hrs/wk CP
Medical Imaging Systems (L0819)	Lecture 4 6
Module Responsible	
Admission Requirements	
Recommended Previous	none
Knowledge	After taking part suggestibly students have reached the following learning results
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can:
	Students can.
	Describe the system configuration and components of the main clinical imaging systems;
	Explain how the system components and the overall system of the imaging systems function;
	Explain and apply the physical processes that make imaging possible and use with the fundamental physical equations;
	Name and describe the physical effects required to generate image contrasts;
	Explain how spatial and temporal resolution can be influenced and how to characterize the images generated;      Transition which improve approximation much also are used to approve improve income.
	Explain which image reconstruction methods are used to generate images;
	Describe and explain the main clinical uses of the different systems.
Skills	Students are able to:
	Explain the physical processes of images and assign to the systems the basic mathematical or physical equations require
	<ul> <li>Calculate the parameters of imaging systems using the mathematical or physical equations;</li> </ul>
	<ul> <li>Determine the influence of different system components on the spatial and temporal resolution of imaging system</li> </ul>
	<ul> <li>Explain the importance of different imaging systems for a number of clinical applications;</li> </ul>
	Select a suitable imaging system for an application.
Personal Competence	
Social Competence	none
Autonomy	Students can:
	Understand which physical effects are used in medical imaging;
	Decide independently for which clinical issue a measuring system can be used.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None www.
Examination	Written exam
Examination duration and	90 min
scale	Flori tradition to a Constitution Market Today to a Flori trade of the Constitution
Assignment for the	
Following Curricula	Biomedical Engineering: Core Qualification: 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
	Troduct Development, Materials and Froduction. Specialisation Materials. Elective Compulsory

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

Module M1179: Medic	cal Basics and Pathology			
Courses				
Title		Тур	Hrs/wk	СР
Medical Basics and Pathology I (L15	599)	Lecture	2	2
Medical Basics and Pathology II (L1	600)	Lecture	2	2
Medical Basics and Pathology III (L1	1602)	Lecture	2	2
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in L	ecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 minutes			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Process Engineering and I	Biotechnology: Elective	Compulsory
Following Curricula	Biomedical Engineering: Core Qualification: Compulsory			

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

Course L1600: Medical Basic	s and Pathology II
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Johannes Kluwe
Language	DE
Cycle	WiSe
Content	Major diseases of
	<ul> <li>the gastrointestinal system and the liver,</li> <li>the hormone system,</li> <li>the kidneys.</li> </ul> The lecture will focus on pathophysiology, symptoms, diagnostic and therapeutic principles of these diseases. 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> II 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> III Kidneys <ul> <li>Functions and failure, diagnostics, principles of renal replacement therapy</li> </ul>
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1602: Medical 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> <li>c) Basic understanding of infectious diseases, immune-system and autoimmune diseases</li> </ul>	
Literature	Skript zur Vorlesung.	

Courses				
Fitle	ant. Materials and Braduction (L1566)	Тур	Hrs/wk	СР
	pent, Materials and Production (L1566)	Practical Course	6	6
Module Responsible				
Admission Requirements Recommended Previous				
Knowledge	Lectures: Mechanics I-III     Lectures: Integrated Product Development  Materials:     Lectures: Structural Metallic Materials, Me     Lectures: Structure and Properties of Pol Composites  Production:     Lecture: Production Engineering     Lectures: Forming and Cutting Technology     Lectures: Machine Tools and Robotic	tallic Materials for Aircraft Applications, Ir ymers, Structure and Properties of Com		
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
<b>Professional Competence</b>				
	represent more complex context of differe     describe functionality of modern measurer		nologies.	
Skills	Students are capable of  applying theoretical knowledge for practic applying provided experimental methods analyzing and evaluating experimental res applying modern measurement instrumen	for examining contexts of different fields sults by using provided methods.	of study.	
Personal Competence Social Competence	Students can  carry out and document experimental wor present and discuss experimental results in		<i>i</i> .	
Autonomy	Students are able to  carry out parts of experimental work indep choose and apply suitable instruments. assess own strengths and weaknesses.	pendently guided by teachers.		
Workload in Hours	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale				
_	Biomedical Engineering: Core Qualification: Com			
Following Curricula	Product Development, Materials and Production:	Core Qualification: Compulsory		

Course L1566: Practical Cour	rse 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. Bodo Fiedler, Prof. Claus Emmelmann, Prof. Dieter Krause, Prof. Gerold Schneider, Prof. Hermann
	Lödding, Prof. Jörg Weißmüller, Prof. Josef Schlattmann, Prof. Michael Morlock, Prof. Otto von Estorff, Prof. Thorsten Schüppstuhl
Language	DE
Cycle	SoSe
Content	Product Development:
	<ul> <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> <li>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> </li> </ul>
	Production:  Optimization of welding process parameters for hybrid plasma laser welding Evaluation of stock removal processes Analysis of basic laws in production logistics Analysis of positioning behaviour and trajectory accuracy of industrial robots
Literature	Nach Themenstellung / depending on topic

Module M1180: Case Studie and Clinical Internship				
Courses				
Title		Тур	Hrs/wk	СР
Casestudies Surgery and Internal M	ledicine (L1603)	Seminar	5	5
Clinical Internship (L1587)		Practical Course	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	The lectures addressing medical issues from the	concentration Biomedical Engineering ir	the respective BSc P	rograms.
Knowledge				
Educational Objectives	After taking part successfully, students have read	thed the following learning results		
Professional Competence				
Knowledge	The students learn the process of clinical practice regarding medical history, diagnosis and treatment decision with representative			
	surgical and medical diseases in the various dep	artments, and get an insight into the d	aily patient care throu	igh case studies in a
	hospital.			
Skills	Interpreting and explaining the medical history a	nd medical records of a patient.		
	Dealing with patients.			
Personal Competence				
Social Competence	Dealing with patients.			
4				
Autonomy	Later and all Start Time Of Start Time in Later	04		
	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points				
Course achievement				
	Written elaboration			
Examination duration and	5 Pages (10 Case studies)			
scale				
-	Biomedical Engineering: Core Qualification: Comp	oulsory		
Following Curricula				

Course L1603: Casestudies S	urgery and Internal Medicine
Тур	Seminar
Hrs/wk	5
СР	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	Die Fallstudien werden in einem 2-wöchentlichen Blockkurs in der Innere und Chirurgie demonstriert. Alle 1-2 Tage wechseln die
	Stationen hierzu gehören:
	- Notaufnahme
	- Intensivstation
	- Pneumologie
	- Gastroenterologie
	- Kardiologie
	- Transfusionsmedizin
	- Poliklinik/Ambulanz
	- Dialyse
	- Unfallchirugie
Literature	keine spezifische

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

Module M1214: Study	ı work	
Courses		
Title	Typ Hrs/wk CP	
Module Responsible	Prof. Michael Morlock	
Admission Requirements	None	
Recommended Previous	Subjects of the Master program and the specialisations.	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	<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 an experienced researcher. They can justify and explain their approach for problem solving; they can draw conclusions from their results, and then can find new ways and methods for their work. Students are capable of comparing and assessing alternative approaches with their own with regard to given criteria.	
Personal Competence		
Social Competence	The students are able to condense the relevance and the structure of the project work, the work procedure and the sub-problems 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 and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.	
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0	
Credit points	12	
Course achievement	None	
Examination	Study work	
Examination duration and	according to FSPO	
scale		
-	Biomedical Engineering: Core Qualification: Compulsory	
Following Curricula		

# **Specialization Implants and Endoprostheses**

Module M0623: Intell	igent Systems in Medicine			
Courses				
<b>Title</b> Intelligent Systems in Medicine (L0 Intelligent Systems in Medicine (L0	334)	<b>Typ</b> Lecture Project Seminar	Hrs/wk 2 2	<b>CP</b> 3 2
Intelligent Systems in Medicine (L0		Recitation Section (small)	1	1
	Prof. Alexander Schlaefer			
Admission Requirements  Recommended Previous  Knowledge	principles of math (algebra, analysis/calculus     principles of stochastics     principles of programming, Java/C++ and R/I     advanced programming skills			
<b>Educational Objectives</b>	After taking part successfully, students have reache	ed the following learning results		
Professional Competence Knowledge	The students are able to analyze and solve clinica optimization, and planning. They are able to explai in clinical contexts. The students can compare diffinithe context of clinical data and explain challeng and safety requirements.	n methods for classification and their resperent methods for representing medical kn	ective advantage owledge. They c	es and disadvantages an evaluate methods
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.			
,	The students discuss the results of other groups, pr The students can reflect their knowledge and documanner.	·		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	e 70		
Credit points	6			
Course achievement	Compulsory Bonus Form Yes 10 % Presentation Yes 10 % Written elaboration	Description		
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	, ,	nology: Elective Compulsory utational Methods in Biomedical Imaging: 0 d Robotics: Elective Compulsory gans and Regenerative Medicine: Elective 0 d Endoprostheses: Elective Compulsory hnology and Control Theory: Elective Computer and Business Administration: Elective Computer Computer and Business Administration: Elective Computer Com	Compulsory oulsory mpulsory	

Course L0331: Intelligent Sy	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 Sy	urse L0334: Intelligent Systems in Medicine		
Тур	Project Seminar		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0333: Intelligent 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

Module M1230: Selec	ted Topics of Biomedical Engineering	J - 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 Appro	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
-	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			

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

Тур	Lecture
Hrs/wk	
СР	
Workload in Hours	
Examination Form	
Examination duration and	
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagatic 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 - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

Course L1588: Development and Regulatory Approval of Medical Devices			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Roman Nassutt		
Language	DE		
Cycle	WiSe		
Content			
Literature	<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 L0377: Experimental Methods in Biomechanics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

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

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes  • Modelling and limits of model  • Time constant, stiffness, stability, step size  • Terms of object orientated programming  • Differential equations of simple systems  • Introduction into Modelica  • Introduction into simulation tool  • Example: Hydraulic systems and heat transfer  • Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>

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

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

Module M0775: Ergon	nomics			
Courses				
Title		Тур	Hrs/wk	СР
Ergonomics (L0653)		Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lec	ture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering: Sp	pecialisation II. Product Development and	Production: Elective Co	ompulsory
Following Curricula	Biomedical Engineering: Specialisation Implant		•	
	Biomedical Engineering: Specialisation Artificia			
	Biomedical Engineering: Specialisation Manage	ement and Business Administration: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Medica	Technology and Control Theory: Elective	e Compulsory	

Course L0653: Ergonomics	ourse L0653: Ergonomics	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Armin Bossemeyer	
Language	DE	
Cycle	WiSe	
Content		
Literature		

Courses				
Title		Тур	Hrs/wk	CP
Intelligent Autonomous Agents and Intelligent Autonomous Agents and		Lecture Recitation Section (small)	2	4 2
	-	Recitation Section (Smail)	2	2
Module Responsible				
Admission Requirements	None			
	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge		define intelligence in terms of rational behavi		
		scribe the main features of environments. The		
		lems and algorithms for solving these problen		
		ow Bayesian networks can be employed as a k		
	,	n addition, students can define decision makir		
		the state of the environment. In this context		
		on problems, and they can recall techniques		
		aneous localization and mapping, and can ex		
		nation problems and decision making in a multi	-agent setting in te	erm of different ty
	of equilibria, social choice functions, voting p	protocol, and mechanism design techniques.		
Skills	Students can select an appropriate agent a	architecture for concrete agent application sce	narios. For simplifi	ied agent applicat
	s 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 Bayesia			
	networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply			
		agent scenarios. For simple and complex dec		
		In multi-agent situations students will apply to		
		decision making students will apply different vo		
	the results.			
Personal Competence				
•	Students are able to discuss their solutions t	to problems with others. They communicate in I	English	
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		, , , , , , , , , , , , , , , , , , , ,	3 -	
Autonomy	Students are able of checking their understa	inding of complex concepts by solving varaints	of concrete proble	ms
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	, , , , , , , , , , , , , , , , , , , ,			
Course achievement	None			
Examination	Written exam			
	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intellige	nce Engineering: Elective Compulsory		
Following Curricula		Specialisation II. Information Technology: Elect	ive Compulsory	
. onowing curricula	Mechatronics: Technical Complementary Co.	•	compaisory	
	Mechatronics: Specialisation Intelligent Syste	' '		
		cial Organs and Regenerative Medicine: Electiv	e Compulsory	
		ants and Endoprostheses: Elective Compulsory	c compaisory	
	3 3 1	cal Technology and Control Theory: Elective Co	mnulsorv	
	Diamedical Engineering. Specialisation Mean	ca co. mology and control micory. Elective co		
	Riomedical Engineering: Specialisation Mana	agement and Business Administration: Elective	Compulsory	

Typ Lecture  Hrs/wk 2  CP 4  Workload in Hours Independent Study Time 92, Study Time in Lecture 28  Lecturer Rainer Marrone  Language EN  Cycle WiSe	
Hrs/wk 2 CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Rainer Marrone Language EN Cycle WiSe	
CP 4 Workload in Hours Independent Study Time 92, Study Time in Lecture 28 Lecturer Rainer Marrone Language EN Cycle WiSe	
Workload in Hours Independent Study Time 92, Study Time in Lecture 28  Lecturer Rainer Marrone  Language EN  Cycle WiSe	
Lecturer Rainer Marrone  Language EN  Cycle WiSe	
Language EN Cycle WiSe	
Cycle WiSe	
Content  Definition of agents, rational behavior, goals, utilities, environment types	
Adversarial agent cooperation:	
Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, ele	ments of
chance	
Uncertainty:	
Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities,	product
rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, co	nplexity,
independence assumptions, naive Bayes, conditional independence assumptions	
Bayesian networks:	
Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typ	ical-case
complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be	directly
perceived).	
Probabilistic reasoning over time:	
Environmental state may change even without the agent performing actions, dynamic Bayesian networks,	
assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely exp	lanation,
special cases: hidden Markov models, Kalman filters, Exact inferences and approximations	
Decision making under uncertainty:  Simple decisions utility theory multivariate utility functions, deminance decision networks, value of information.	
Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio  Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs	
Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks	
Simultaneous Localization and Mapping	
Planning	
Game theory (Golden Balls: Split or Share)	
Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium	
Social Choice	
Voting protocols, preferences, paradoxes, Arrow's Theorem,	
Mechanism Design	
Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility T	heorem,
Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected ex	ternality
mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satte	rthwaite
Theorem	
1 th a real and	
Literature  1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters	2-5, 10-
11, 13-17	
2. Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005	
2. Multiagent Customer Algorithmic Correction and Legical Foundations. Very Challenge V. 1919 1919 2019	oo lo wi -l :
3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cal	nbriage
University Press, 2009	

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
<b>Admission Requirements</b>	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	2 Engineering Meenanies			
<b>Educational Objectives</b>	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vibrat	ion Theory and develop them fur	rther.	
Skills	Students are able to denote methods of Vibration Theory	and develop them further.		
Personal Competence				
,	Students can reach working results also in groups.			
	Students are able to approach individually research tasks	in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory			
Following Curricula			•	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compulso	ory	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs at	-		
	Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technolog			
	Biomedical Engineering: Specialisation Management and	•		
	Product Development, Materials and Production: Core Qui		compulsory	
	Naval Architecture and Ocean Engineering: Core Qualifica	' '		
	Theoretical Mechanical Engineering: Core Qualification: E			

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

Module M0808: Finite	e Elements Methods
Courses	
Courses	Tue Healink CD
<b>Title</b> Finite Element Methods (L0291)	Typ Hrs/wk CP  Lecture 2 3
Finite Element Methods (L0804)	Recitation Section (large) 2 3
Module Responsible	
Admission Requirements	
Recommended Previous	
Knowledge	
Kilowicage	Madicinates 1, 11, 111 paraedial anterential equations)
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to giv overview of the theoretical and methodical basis of the method.
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the correspor system matrices, and solving the resulting system of equations.
	Students can work in small groups on specific problems to arrive at joint solutions.  The students are able to independently solve challenging computational problems and develop own finite element rout Problems can be identified and the results are critically scrutinized.
Workload in Hours	
Credit points	
Course achievement	
E contraction	No 20 % Midterm
Examination	
Examination duration and	
scale	
=	Civil Engineering: Core Qualification: Compulsory
Following Curricula	
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory
	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory
	Aircraft Systems Engineering: Core Qualification: Elective Compulsory
	International Management and Engineering: Specialisation II. Mechatronics: Elective 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	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering
	- Displacement method
	- Hybrid formulation
	- Isoparametric elements
	- Numerical integration
	- Solving systems of equations (statics, dynamics)
	- Eigenvalue problems
	- Non-linear systems
	- Applications
	- Programming of elements (Matlab, hands-on sessions)
	- Applications
Literature	Bathe, KJ. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0804: Finite 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 M0814: Tech	nology Management				
Causaa					
Courses		T	Hara facilis	CD.	
<b>Fitle</b> Technology Management (L0849)		<b>Typ</b> Lecture	Hrs/wk 3	<b>CP</b> 3	
echnology Management Seminar	(L0850)	Project-/problem-based Learning	2	3	
Module Responsible	Prof. Cornelius Herstatt				
Admission Requirements	None				
Recommended Previous	Bachelor knowledge in business management				
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have reach	ed the following learning results			
<b>Professional Competence</b>					
Knowledge	Students will gain deep insights into:				
	International R&D-Management				
	Technology Timing Strategies				
	<ul> <li>Technology Strategies and Lifecycle Management (I/II)</li> <li>Technology Intelligence and Planning</li> <li>Technology Portfolio Management</li> <li>Technology Portfolio Methodology</li> <li>Technology Acquisition and Exploitation</li> </ul>				
	IP Management				
	Organizing Technology Development     Technology Organization & Management				
	Technology Granization & Manageme     Technology Funding & Controlling	ent			
Skills	The course aims to:				
	Develop an understanding of the importance	e of Technology Management - on a national	as well as inter	national level	
	<ul> <li>Equip students with an understanding of important elements of Technology Management (strategic, operations organizational and process-related aspects)</li> <li>Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and i importance for corporate strategy</li> </ul>				
	Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation)				
	<ul> <li>Strengthen essential communication skills and a basic understanding of managerial, organizational and financia concerning Technology-, Innovation- and R&amp;D-management. Further topics to be discussed include:</li> </ul>				
	Basic concepts, models and tools, relevant to	o the management of technology, R&D and i	nnovation		
	Innovation as a process (steps, activities and	d results)			
Barranal Carranton					
Personal Competence Social Competence					
Social Competence	Interact within a team				
	Raise awareness for globabl issues				
Autonomy					
riaconomy	Gain access to knowledge sources				
	Discuss recent research debates in the conte	ext of Technology and Innovation Manageme	nt		
	Develop presentation skills				
	Discussion of international cases in R&D-Mar	nagement			
Workload in Hours	Independent Study Time 110, Study Time in Lectur	re 70			
Credit points	6				
Course achievement	None				
Examination	Written exam		-		
Examination duration and	90 minutes				
scale					
Assignment for the					
Following Curricula	International Management and Engineering: Special		mpulsory		
	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 Implants and		lsorv		
	Biomedical Engineering: Specialisation Managemer		,		

Course L0849: Technology M	anagement
Тур	Lecture
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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	anagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
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
Microsystems Technology (L0724)				Lecture	2	4
Microsystems Technology (L0725)	T			Project-/problem-based Learning	2	2
Module Responsible						
Admission Requirements						
Recommended Previous	1, 3, 11, 1	mistry, mechanics and s	emiconductor techr	nology		
Knowledge						
Educational Objectives		essfully, students have r	eached the followin	g learning results		
Professional Competence						
Knowledge	Students are able					
	· ·	·	•	or microstructures and especia of in more complex systems	illy methods fo	or the fabrication o
	to explain in deta	ils operation principles o	f microsensors and	microactuators and		
	to discuss the pot	ential and limitation of r	nicrosystems in app	lication.		
Skills	Students are capable					
	<ul> <li>to analyze the feat</li> </ul>	sibility of microsystems	,			
	to develop proces	ss flows for the fabrication	on of microstructure	s and		
	• to apply them					
	to apply them.					
Personal Competence Social Competence		prepare and perform the	ir lab experiments i	n team work as well as to preso	ent and discuss	s the results in fror
Autonomy	None					
Workload in Hours		me 124, Study Time in L	ecture 56			
Credit points		Form	Description			
Course achievement	Yes None	Subject theoretical practical work	andStudierenden	führen in Kleingruppen ein La d diskutiert die Theorie sowie o mten Kurs.	•	
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Electrical Engineering	: Specialisation Nanoele	ctronics and Microsy	stems Technology: Elective Co	mpulsory	
Following Curricula	Electrical Engineering	: Specialisation Medical	Technology: Elective	e Compulsory		
	International Manager	ment and Engineering: S	pecialisation II. Mec	hatronics: Elective Compulsory		
	_	• .	·	ses: Elective Compulsory		
	Letter and the state of the sta	ng: Specialisation Medica	I Technology and C	ontrol Theory: Elective Compuls	sorv	
	Biomedical Engineerin	ng: Specialisation Manag	ement and Business	s Administration: Elective Comp nerative Medicine: Elective Com	ulsory	

ourse 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	
Content	
	Introduction (historical view, scientific and economic relevance, scaling laws)
	Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation)
	lithography, nano-imprinting, molecular imprinting)
	Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVI     The state of the state o
	techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)
	Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching anicotropic etching with KOLUTMALL, theory, corner undersutting measures for companyation and etch too techniques.
	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)
	<ul> <li>Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures</li> </ul>
	Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping)
	Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile)
	modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer
	mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)
	Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor
	piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rat
	sensor: operating principle and fabrication process)
	<ul> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistiv sensors: magneto resistance, AMR and GMR, fluxgate magnetometer)</li> </ul>
	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 clash all standa consuma all attacks.
	Clark electrode, enzyme electrode, DNA chip)  • Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators
	DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokineti
	micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a chip, microanalytics)
	<ul> <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> </ul>
	<ul> <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-tu</li> </ul>
	relationship)  • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding the state of the state
	and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Course L0725: Microsystems	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		

Module M0846: Contr	ol Systems Theory and Desig	n		
Courses				
<b>Title</b> Control Systems Theory and Desig Control Systems Theory and Desig		<b>Typ</b> Lecture Recitation Section (small)	Hrs/wk 2 2	<b>CP</b> 4 2
Module Responsible		Nectation Section (small)	2	2
Admission Requirements				
	Introduction to Control Systems			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	ve reached the following learning results		
Professional Competence  Knowledge				
Skills	response to initial states or external  They can explain the system proper estimation, respectively  They can explain the significance of  They can explain observer-based state  They can extend all of the above to  They can explain the z-transform an  They can explain state space models  They can explain the experimental in the solved by solving a normal equate  They can explain how a state space  Students can transform transfer function of the can design LQG controllers for  They can design LQG controllers for  They can carry out a controller des for a given sampling rate  They can identify transfer function in	ate feedback and how it can be used to achieve multi-input multi-output systems d its relationship with the Laplace Transform is and transfer function models of discrete-time identification of ARX models of dynamic systems ion model can be constructed from a discrete-time detection models into state space models and vice vobservability and construct minimal realisations	relationship to state tracking and disturb systems s, and how the ident impulse response ersa lomain, and decide	e feedback and state  pance rejection  ification problem can  which is appropriate
	when solving given problems.	vided sources (lecture notes, software docum		nt guides) and use i
	They can assess their knowledge in weekly	on-line tests and thereby control their learning	progress.	
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and				
Scale Assignment for the	Electrical Engineering: Core Qualification: 0	Compulsory		
-	Energy Systems: Core Qualification: Elective			
<b>3</b>	Aircraft Systems Engineering: Core Qualific Computational Science and Engineering: SI International Management and Engineering International Management and Engineering Mechanical Engineering and Management: Mechatronics: Core Qualification: Compulso Biomedical Engineering: Specialisation Arti Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Med Biomedical Engineering: Specialisation Mar	cation: Elective Compulsory pecialisation II. Engineering Science: Elective Co g: Specialisation II. Electrical Engineering: Electiv g: Specialisation II. Mechatronics: Elective Comp Specialisation Mechatronics: Elective Compulso	ve Compulsory ulsory ry ve Compulsory	

Typ	Lecture
Hrs/wk	
СР	4
	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
	<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
Literature	Werner, H., Lecture Notes "Control Systems Theory and Design"
	T. Kailath "Linear Systems", Prentice Hall, 1980  T. Kailath "Linear Systems", Prentice Hall, 1980
	K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997
	L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

Course L0657: Control Syste	ourse L0657: Control Systems Theory and Design		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	2		
Workload in Hours	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		

lodule M0867: Produ	iction Planning & Control and	d Digital Enterprise		
Courses				
litle little		Тур	Hrs/wk	СР
he Digital Enterprise (L0932)		Lecture	2	2
roduction Planning and Control (L	0929)	Lecture	2	2
roduction Planning and Control (L		Recitation Section (small)	1	1
xercise: The Digital Enterprise (L0	933)	Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
<b>Recommended Previous</b>	Fundamentals of Production and Quality N	Management		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students ha	ave reached the following learning results		
<b>Professional Competence</b>				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineerin	ng: Specialisation II. Product Development and Prod	uction: Elective C	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spe	cialisation Production and Logistics: Elective Compu	ılsory	
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Compulso	ry	
	Product Development, Materials and Prod	luction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Prod	luction: Specialisation Production: Compulsory		
	Product Development, Materials and Prod	luction: Specialisation Materials: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Spec	cialisation Product Development and Production: Ele	ctive Compulsory	

Course L0932: The Digital Er	nterprise
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 Pl	anning and Control
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<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 Pl	ourse 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	Recitation Section (small)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	Siehe korrespondierende Vorlesung
	See interlocking course

Module M0921: Electi	ronic Circuits fo	or Medical Applica	ations			
Courses						
Title				Тур	Hrs/wk	СР
Electronic Circuits for Medical Applications (L0696)				Lecture	2	3
Electronic Circuits for Medical Appli				Recitation Section (small)	1	2
Electronic Circuits for Medical Appli	ications (L1408)			Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl					
Admission Requirements	None					
Recommended Previous		trical engineering				
Knowledge						
Educational Objectives	After taking part succ	essfully, students have re	eached the following	ng learning results		
Professional Competence						
Knowledge	Students can e Students are a Students can e Students can d Students can e	ble to explain the build-u exemplify the communical lescribe the special featur explain the functions of pr	p of an action pote tion between neur res of low-noise ar costheses, e. g. an	ation transfer by the central ential and its propagation ald ons and electronic devices nplifiers for medical applicat artificial hand of cochlea implants and artif	ong an axon	
Skills	<ul><li>Students can g</li><li>Students can g</li><li>Students can g</li></ul>		improvement of lons of prosthetic sy		al acquisition.	
Personal Competence Social Competence	Students are t professional ba     Students are a	ackground. ble to recognize their spe document their work in a	cific limitations, so	nedical electronics in teams o that they can ask for assist d communicate their results	tance to the right t	ime.
Autonomy	Students are necessary.      Students can b     Students can h	reak down their work in a	appropriate work p	their knowledge and to de packages and schedule their ectrical experiments without les and situations of experim	work in a realistic needing support.	
Workload in Hours	Independent Study Ti	me 124, Study Time in Le	ecture 56			
Credit points						
Course achievement	Yes None  No None	Form Subject theoretical practical work Excercises	<b>Description</b> and			
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the		: Specialisation Medical 1				
Following Curricula	_			enerative Medicine: Elective	Compulsory	
	_	• .	·	eses: Elective Compulsory		
	_	-	-	Control Theory: Compulsory		
	_	- ,		ss Administration: Elective C		
				ics Complements: Elective C		
	Theoretical Mechanic	al Engineering: Specialisa	ition Bio- and Med	ical Technology: Elective Co	mpulsory	

Course L0696: Electronic Circ	cuits 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

Course L1408: Electronic Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<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/

Module M1150: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g., in	the module Mechanics II (forces and	moments, stres	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain ene	ergy).		
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to ca	alculate the mechanical behavior of n	naterials.	
Skills	The students can set up balance laws and apply basics research contexts.	of deformation theory to specific as	pects, both in a	oplied contexts as in
Personal Competence				
Social Competence	The students are able to develop solutions, to present th	em to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own strengths and problems in the area of continuum mechanics and acquir	•		vn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Com	pulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation			
	Mechatronics: Technical Complementary Course: Elective			
	Biomedical Engineering: Specialisation Artificial Organs a	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and End		To a constant of the constant	
	Biomedical Engineering: Specialisation Medical Technolo		•	
	Biomedical Engineering: Specialisation Management and Product Development, Materials and Production: Core Qu		привогу	
	Theoretical Mechanical Engineering: Core Qualification: E			
	medical Mechanical Engineering. Core Qualification:	lective compulsory		

Course L1533: Continuum Me	echanics
Тур	Lecture
Hrs/wk	2
	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Christian Cyron
Language	
Cycle	WISE
Content	Fundamentals of tensor calculus
	Transformation invariance
	Tensor algebra
	Tensor analysis
	Kinematics
	Motion of continuum
	<ul> <li>Deformation of infinitesimal line, area and volume elements</li> </ul>
	Material and spatial description
	Polar decomposition
	Spectral decomposition
	Objectivity
	Strain measures
	Time derivatives
	<ul> <li>Partial / material time derivatives</li> </ul>
	<ul> <li>Objective time rates</li> </ul>
	<ul><li>Strain and deformation rates</li></ul>
	Transport theorems
	Balance equations (global and local form)
	Balance of mass
	The stress state
	<ul> <li>Surface traction vectors</li> </ul>
	<ul> <li>Cauchy's fundamental theorem</li> </ul>
	<ul><li>Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)</li></ul>
	Balance of linear momentum
	Balance of angular momentum
	Balance of energy
	Balance of entropy
	Clausius-Duhem inequality
	Constitutive laws
	Constitutive assumptions
	• Fluids
	Elastic solids
	Hyperelasticity
	Material symmetry
	Elasto-plastic solids     Analysis
	Analysis  A laitial boundary value problems and their numerical solution.
	<ul> <li>Initial-boundary value problems and their numerical solution</li> </ul>
	D. Carrier Kanting on a should. Fig. Carried over \$10 be a salar over on \$100 bit.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer
	weitere siehe in der Literaturliste des Scripts
	weitere siehe in der Literaturliste des Scripts

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

Module M1151: Mate	rials Modeling
Courses	
Title	Typ Hrs/wk CP
Material Modeling (L1535)	Lecture 2 3
Material Modeling (L1536)	Recitation Section (small) 2 3
Module Responsible	Prof. Christian Cyron
Admission Requirements	None
<b>Recommended Previous</b>	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (for
Knowledge	and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)
Educational Objectives	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowled
	to various problems of material science and evaluate the corresponding material models.
Personal Competence	
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and so
	problems in the area of materials modeling and acquire the knowledge required to this end.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	
Examination	
Examination duration and scale	
Assignment for the	
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory  Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Product Development, Materials and Production: Core Qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

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

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

Module M1199: Adva	nced Functional Materials
Courses	
Title	Typ Hrs/wk CP
Advanced Functional Materials (L16	625) Seminar 2 6
Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in 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 ne
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview o
	modern materials science, which enables them to select optimum materials combinations depending on the technical
	applications.
Personal Competence	
_	The students are able to present solutions to specialists and to develop ideas further.
Social competence	The stadents are able to present solutions to specialists and to develop facus farmer.
Autonomy	The students are able to
	assess their own strengths and weaknesses.
	gather new necessary expertise by their own.
Wantdaad in Harris	Independent Child. Time 172 Child. Time in Latitus 20
Credit points Course achievement	
Examination	
Examination duration and	
scale	
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
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	563)	Seminar	2	3
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
-	Biomedical Engineering: Specialisation Medical Techn		pulsory	

Course L1663: Nature's Hiera	archical Materials
	Seminar
Hrs/wk	
CP	
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	
СР	
Workload in Hours	
Examination Form	
Examination duration and	
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagatic 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 - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

Course L1588: Development and Regulatory Approval of Medical Devices		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Roman Nassutt	
Language	DE	
Cycle	WiSe	
Content		
Literature	<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 L0377: Experimental Methods in Biomechanics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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	schriftliche ausarbeitung und Vortrag (20 min)
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

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

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes  • Modelling and limits of model  • Time constant, stiffness, stability, step size  • Terms of object orientated programming  • Differential equations of simple systems  • Introduction into Modelica  • Introduction into simulation tool  • Example: Hydraulic systems and heat transfer  • Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>

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

Course L0379: Ceramics Tecl	hnology		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
	Dr. Rolf Janßen		
Language			
Cycle		sing with amphasis an advanced structural coronics. The source facus prodominatly an newdor	
	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: Inhalt:	Introduction     Raw materials	
	Titlate.		
	3. Powder fabrication		
	Powder processing     Shape-forming processes		
		6. Densification, sintering	
		7. Glass and Cement technology	
		8. Ceramic-metal joining techniques	
Literature	W.D. Kingery, "Introduction to C	eramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991		
	D.W. Richerson, "Modern Ceram	nic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

	I: Introduction to Biochemis			
Courses				
Title		Тур	Hrs/wk	СР
Introduction to Biochemistry and M	olecular Biology (L0386)	Lecture	2	3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
<b>Recommended Previous</b>	None			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students h	ave reached the following learning results		
<b>Professional Competence</b>				
Knowledge	The students can			
	<ul> <li>describe basic biomolecules;</li> </ul>			
	<ul> <li>explain how genetic information is</li> </ul>	coded in the DNA:		
	explain the connection between D			
Skills	The students can			
	recognize the importance of molecular	cular parameters for the course of a disease;		
	describe selected molecular-diagn			
	explain the relevance of these pro			
Personal Competence				
Social Competence	The students can participate in discussion	ns in research and medicine on a technical lev	el.	
Autonomy	The students can develop understanding	of topics from the course, using technical liter	rature, by themselves.	
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German pr	ogram, 7 semester): Specialisation Biomedical	Engineering: Compulsor	У
Following Curricula	General Engineering Science (German	program, 7 semester): Specialisation Mecl	hanical Engineering, Fo	cus Biomechanics
	Compulsory			
	Data Science: Specialisation Medicine: Co	ompulsory		
	Electrical Engineering: Specialisation Med			
	Engineering Science: Specialisation Biom	edical Engineering: Compulsory		
	General Engineering Science (English pro	ogram, 7 semester): Specialisation Biomedical	Engineering: Compulsory	/
	General Engineering Science (English	program, 7 semester): Specialisation Mech	hanical Engineering, Fo	cus Biomechanics
	Compulsory			
	Mechanical Engineering: Specialisation B	iomechanics: Compulsory		
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Elect	tive Compulsory	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Elective	e Compulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compuls	sory	
	Technomathematics: Specialisation III. Er	aginopring Science: Flactive Compulsory		

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

Module M1334: BIO II	: Biomaterials		
Courses			
Title	Typ Hrs/wk CP		
Biomaterials (L0593)	Lecture 2 3		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is recommended.		
Knowledge			
<b>Educational Objectives</b>	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	90 min		
scale			
Assignment for the	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory		
Following Curricula	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: Specialisation Bio- and Medical Technology: Elective Compulsory		

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

Module M1342: Polyn	ners			
Courses				
Fitle	ore (1.0390)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Structure and Properties of Polyme Processing and design with polyme		Lecture	2	3
Module Responsible				
Admission Requirements	None			
	Basics: chemistry / physics / material scie	nce		
Knowledge	, , , , , , , , , , , , , , , , , , ,			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
<b>Professional Competence</b>				
Knowledge	Students can use the knowledge of plastic	cs and define the necessary testing and analysi	s.	
	They can explain the complex relationship	os structure-property relationship and		
	the interactions of chemical structure of the protection).	he polymers, including to explain neighboring o	contexts (e.g. sustaina	bility, environmenta
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.			
	- arrive at runded work results in neteroge	enius 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 weaknes	sses.		
	- assess their own state of learning in spe	cific terms and to define further work steps on	this basis.	
	- assess possible consequences of their pr	rofessional activity.		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Materials Science: Specialisation Engineer	ring Materials: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Im			
		tificial Organs and Regenerative Medicine: Elec		
		anagement and Business Administration: Election		
		edical Technology and Control Theory: Elective		
	i '	uction: Specialisation Production: Elective Com		
	' '	uction: Specialisation Materials: Elective Comp	,	
	· ·	uction: Specialisation Product Development: El		
	Trieoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compulso	гу	

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

Course L1892: Processing an	d 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

Carrena					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (L166	1)	Seminar Seminar	2	3 3
Module Responsible					
Admission Requirements					
Recommended Previous					
Knowledge	None				
Educational Objectives	After taking part suc	cessfully, students have re	ached the following learning results		
Professional Competence	7 ites taking part sac	eessiany, stadents nave re	action the tenering realiting results		
	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods the cultivation of animal and human cells.				
		utline the actual concept of the discussed topics.	ts of Tissue Engineering and regener	ative medicine and ca	n explain the bas
Skills	After successful completion of the module students are  able to use medical databases for acquirierung and presentation of relevant up-to-date data independently  able to present their work results in the form of presentations  able to carry out basic cell culture methods and the corresponding analysis independently  able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine.				
Personal Competence Social Competence	defend them.		with 2-4 students to solve given tasks and discuss it with other students and tea		in the plenary and
Autonomy	· ·	this module, participant ing a presentation of the r	s will be able to solve a technical pesults.	problem in teams of a	approx. 2-4 perso
Workload in Hours	Independent Study T	ime 124, Study Time in Le	cture 56		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pr	otocol for lecture series	
Examination	Presentation				
Examination duration and	Oral presentation +	discussion (30 min)			
scale					
Assignment for the	Biomedical Engineer	ng: Specialisation Implant	s and Endoprostheses: Elective Compuls	sory	
Following Curricula	Biomedical Engineer	ng: Specialisation Artificia	Organs and Regenerative Medicine: Co	mpulsory	
	Biomedical Engineer	ng: Specialisation Manage	ment and Business Administration: Elec	tive Compulsory	
	Biomedical Engineer	ng: Specialisation Medical	Technology and Control Theory: Electiv	e Compulsory	

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

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

Module M1333: BIO I:	Implants and Fracture Healing		
Courses			
Title	Typ Hrs	/wk	СР
Implants and Fracture Healing (L03	276) Lecture 2		3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fract	ure Healing	".
Knowledge			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existenc	e.	
	The students can name different treatments for the spine and hollow bones under given fracture morphisms.	hologies.	
CI:II-			
SKIIIS	The students can determine the forces acting within the human body under quasi-static situations und	ier specific	assumptions.
Personal Competence			
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces	5.	
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces	5.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and	90 min		
scale			
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engine	ering, Foc	us Biomechanio
Following Curricula	Compulsory		
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: C	Compulsory	
	Engineering Science: Specialisation Biomedical Engineering: Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Co	ompulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engine	ering, Foci	us Biomechanio
	Compulsory		
	Mechanical Engineering: Specialisation Biomechanics: Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulso	ory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsor		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	,	
	Orientation Studies: Core Qualification: Elective Compulsory		
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0376: Implants and	Fracture Healing			
Тур	Lecture			
Hrs/wk				
СР				
	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	rof. Michael Morlock E			
Cycle				
Content	Topics to be covered include:			
	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)			
	Fracture Healing			
	1 Basics and biology of fracture repair			
	5.2 Clinical principals and terminology of fracture treatment			
	5.3 Biomechanics of fracture treatment			
	5.3.1 Screws			
	5.3.2 Plates			
	5.3.3 Nails			
	5.3.4 External fixation devices			
	5.3.5 Spine implants			
	6.0 New Implants			
Literature	Cochran V.B.: Orthopädische Biomechanik			
Literature	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics			
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine			
	Nigg, B.: Biomechanics of the musculo-skeletal system			
	Schiebler T.H., Schmidt W.: Anatomie			
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat			
	The second secon			

Module M0630: Robot	tics and Naviga	tion in Medicine			
Courses					
Title  Robotics and Navigation in Medicine (L0335)  Robotics and Navigation in Medicine (L0338)  Robotics and Navigation in Medicine (L0336)			<b>Typ</b> Lecture Project Seminar Recitation Section (smal	Hrs/wk 2 2 1	CP 3 2 1
Module Responsible	Prof. Alexander Schla	efer			
Admission Requirements	None				
Recommended Previous Knowledge	<ul> <li>principles of p</li> </ul>	<ul> <li>principles of math (algebra, analysis/calculus)</li> <li>principles of programming, e.g., in Java or C++</li> <li>solid R or Matlab skills</li> </ul>			
Educational Objectives	After taking part succ	cessfully, students have re	ached the following learning results		
	detail. Systems can systems regarding de	be evaluated with respect esign and limitations.	king systems in clinical contexts and il it to collision detection and safety and avigation systems and robotic systems fo	regulations. Studen	ts can assess typical
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.  The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study T	ime 110, Study Time in Le	cture 70		
Credit points	6				
Course achievement	Compulsory Bonus Yes 10 % Yes 10 %	Form Presentation Written elaboration	Description		
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the	Computer Science: S	pecialisation II: Intelligence	e Engineering: Elective Compulsory		
	International Manage Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen	ment and Engineering: Sp lisation Intelligent System ng: Specialisation Artificial ng: Specialisation Implant: ng: Specialisation Medical ng: Specialisation Manage t, Materials and Production t, Materials and Production	ecialisation II. Electrical Engineering: Elec ecialisation II. Process Engineering and B is and Robotics: Elective Compulsory Organs and Regenerative Medicine: Elec is and Endoprostheses: Elective Compulso Technology and Control Theory: Elective ment and Business Administration: Elective it: Specialisation Product Development: El it: Specialisation Production: Elective Com	iotechnology: Elective ctive Compulsory ory Compulsory ve Compulsory ective Compulsory ipulsory	c Compulsory
	l		n: Specialisation Materials: Elective Comp ion Bio- and Medical Technology: Electiv	•	

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

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

Course L0336: Robotics and 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	

Module M1384: Case	Studies for Regenerative Medi	cine and Tissue Engineering		
Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artific	ial Organs and Regenerative Medicine: Com	pulsory	
Following Curricula	Biomedical Engineering: Specialisation Impla		•	
	Biomedical Engineering: Specialisation Mana	-		
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Elective (	Compulsory	

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

Module M0634: Introd	duction into Me	edical Technolo	gy and System	s		
Courses						
Title				Тур	Hrs/wk	СР
Introduction into Medical Technolog	gy and Systems (L0342)			Lecture	2	3
Introduction into Medical Technolog				Project Seminar	2	2
Introduction into Medical Technolog				Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous		lgebra, analysis/calculu	ıs)			
Knowledge	principles of stochas					
	principles of program	ıming, R/Matlab				
Educational Objectives	After taking part suc	cessfully, students hav	e reached the followin	g learning results		
Professional Competence	31			3		
-	The students can ex	kplain principles of me	edical technology, inc	luding imaging systems,	computer aided s	surgery, and medica
-				ory affairs and standards i		
	-					
Skills	The students are abl	e to evaluate systems	and medical devices ir	the context of clinical app	lications.	
Personal Competence						
Social Competence	The students describ	e a problem in medica	l technology as a proje	ect, and define tasks that a	re solved in a joint	t effort.
Autonomy						
	manner.					
Workload in Hours	Independent Study T	ime 110, Study Time in	n Lecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the				cialisation Biomedical Engi		ory
Following Curricula	·		•	ering: Elective Compulsory		
	·	•		g Science: Elective Compul	sory	
	Data Science: Core Qualification: Elective Compulsory					
	Electrical Engineering: Core Qualification: Elective Compulsory					
	Engineering Science: Specialisation Biomedical Engineering: Compulsory  General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory					
	Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory  Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory					
	_			ses: Elective Compulsory	paisor,	
	•		·		npulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory  Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
	_	Specialisation III. Engi				

Course L0342: Introduction i	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	- imaging systems			
	- computer aided surgery			
	- medical sensor systems			
	- medical information systems			
	- regulatory affairs			
	- standard in medical technology			
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.			
Literature	Wird in der Veranstaltung bekannt gegeben.			

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

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

Module M0752: Nonlin	near Dynamics				
Courses					
Title		Тур	Hrs/wk	СР	
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6	
Module Responsible	Prof. Norbert Hoffmann				
<b>Admission Requirements</b>	None				
Recommended Previous	Calculus				
Knowledge	Calculus     Linear Algebra				
	Engineering Mechanics				
	2 Engineering Mechanics				
<b>Educational Objectives</b>	After taking part successfully, students have reached the	e following learning results			
<b>Professional Competence</b>					
Knowledge	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms are				
	concepts.				
Skills	Students are able to apply existing methods and process	ures of Nonlinear Dynamics and to	develop novel meth	ods and procedures.	
Personal Competence					
Social Competence	Students can reach working results also in groups.				
Autonomy	Students are able to approach given research tasks indi	vidually and to identify and follow t	up novel research ta	sks by themselves.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Aircraft Systems Engineering: Core Qualification: Electiv	e Compulsory			
Following Curricula	International Management and Engineering: Specialisati	on II. Mechatronics: Elective Comp	ulsory		
	Mechanical Engineering and Management: Specialisation	·	ry		
	Mechatronics: Specialisation System Design: Elective Co				
	Mechatronics: Specialisation Intelligent Systems and Rol				
	Biomedical Engineering: Specialisation Artificial Organs	-	re Compulsory		
	Biomedical Engineering: Specialisation Implants and Engineering: Specialisation Medical Tachnel		manula an i		
	Biomedical Engineering: Specialisation Medical Technology	•			
	Biomedical Engineering: Specialisation Management and Product Development, Materials and Production: Core Qu		Compuisory		
	Theoretical Mechanical Engineering: Core Qualification:				
	meoretical Mechanical Engineering. Core Qualification:	Licetive Compuisory			

Course L0702: Nonlinear Dyr	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 Technology (L0722 Semiconductor Technology (L0723		Lecture Practical Course	4	4 2	
Module Responsible		Tractical Course	-	2	
Admission Requirements					
Recommended Previous		ductor devices			
Knowledge		adetor devices			
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results			
Professional Competence					
Knowledge					
	Students are able				
	to describe and to explain current fabrication technique	es for Si and GaAs substrates	,		
	• to discuss in details the relevant fabrication pro	cesses, process flows and t	the impact thereof or	n the fabrication	
	semiconductor devices and integrated circuits and				
	to present integrated process flows.				
	to present integrated process nows.				
Skills					
	Chudanha ara assabla				
	Students are capable				
	to analyze the impact of process parameters on the process.	cessing results,			
	to select and to evaluate processes and				
	to develop process flows for the fabrication of semicon	ductor devices.			
Personal Competence					
Social Competence					
Social Competence					
	Students are able to prepare and perform their lab experin	ents in team work as well as	to present and discus	s the results in fro	
	of audience.				
Autonomy	None				
	Independent Study Time 96, Study Time in Lecture 84				
Credit points					
Course achievement					
Examination					
Examination duration and					
scale					
Accionment for the	Electrical Engineering, Specialisation Naposlastra-i d	Nicrosystoms Tashaalaa [1-	ctivo Compulsory		
Assignment for the Following Curricula					
i onowing curricula	Biomedical Engineering: Specialisation Implants and Endop	3	, ,		
	Biomedical Engineering: Specialisation Medical Technology				
	Biomedical Engineering: Specialisation Management and Bu	•			
	Microelectronics and Microsystems: Core Qualification: Elec	tive Compulsory			

0722: Semiconducto				
Тур				
Hrs/wk				
Orkload in Hours	Independent Study Time 64, Study Time in Lecture 56			
	Prof. Hoc Khiem Trieu			
Language				
Cycle				
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, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dama annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetinfluences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs)</li> </ul>			
	<ul> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinet temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacue evaporation, sputtering)</li> </ul>			
	<ul> <li>Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxim and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique a electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, elect beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic a anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchi backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> </ul>			
	Process integration (CMOS process, bipolar process)			
	<ul> <li>Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical conta wire bonding, TAB and flip chip, wafer level package, 3D stacking)</li> </ul>			
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons			
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons			
	H. Hilleringmann, Cilizium Halbleitertechnologie, Taubner Verlag			
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag			
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag			
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin			
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press			
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill			

Course L0723: Semiconducto	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	

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	<ul> <li>Introduction to control systems</li> </ul>			
	Control theory and design			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students can explain humanoid robots	5.		
		concepts for different tasks in humanoid ro	botics.	
GL'III.				
Skills	Students acquire knowledge about sel	ected aspects of humanoid robotics, based	d on specified literature	
	<ul> <li>Students generalize developed results</li> </ul>	and present them to the participants		
	<ul> <li>Students practice to prepare and give</li> </ul>	a presentation		
Personal Competence				
Social Competence				
Social competence	<ul> <li>Students are capable of developing so</li> </ul>	lutions in interdisciplinary teams and pres	ent them	
	<ul> <li>They are able to provide appropriate f</li> </ul>	eedback and handle constructive criticism	of their own results	
Autonomy				
	<ul> <li>Students evaluate advantages and of</li> </ul>	drawbacks of different forms of presenta	tion for specific tasks	and select the best
	solution			
		a scientific field, are able of introduce it	and follow presentation	ns of other students,
	such that a scientific discussion develo	ops		
Workload in Hours	Independent Study Time 32, Study Time in L	ecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min	·		
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design:	• •		
	Biomedical Engineering: Specialisation Artific	•		
	Biomedical Engineering: Specialisation Impla			
	Biomedical Engineering: Specialisation Medic			
	Biomedical Engineering: Specialisation Mana		. ,	
	Theoretical Mechanical Engineering: Speciali	sation Robotics and Computer Science: Ele	ective Compulsory	

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

Courses					
Title		Тур	Hrs/wk	СР	
Linear and Nonlinear System Ident		Lecture	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	<ul> <li>Classical control (frequency residue)</li> </ul>	ponse, root locus)			
Knowledge	State space methods	, , ,			
	Discrete-time systems				
	Linear algebra, singular value d	ecomposition			
	Basic knowledge about stochast	tic processes			
Educational Objections	After telling and every set all a students	a beautiful and the fall accions because a secultar			
Educational Objectives Professional Competence	Arter taking part successfully, students	s have reached the following learning results			
Knowledge					
Knowieage	<ul> <li>Students can explain the gene</li> </ul>	ral framework of the prediction error method	and its application to a	variety of linear a	
	nonlinear model structures				
	They can explain how multilaye	r perceptron networks are used to model nonlir	near dynamics		
		ximate predictive control scheme can be based		s	
	They can explain the idea of subspace identification and its relation to Kalman realisation theory				
Skills					
		ing the predicition error method to the exper	imental identification of	linear and nonline	
models for dynamic systems					
	i i	ing a nonlinear predictive control scheme based			
	<ul> <li>They are capable of applying subspace algorithms to the experimental identification of linear models for dy</li> <li>They can do the above using standard software tools (including the Matlab System Identification Toolbox)</li> </ul>				
	• They can do the above using sta	andard software tools (including the Matiab Sys	stem identification 100ibo.	x)	
Personal Competence					
Social Competence	Students can work in mixed groups on	specific problems to arrive at joint solutions.			
Autonomy	Students are able to find required info	ormation in sources provided (lecture notes, lite	rature software documer	ntation) and use it	
riaconomy	solve given problems.	ation in Sources provided (rectare notes, inc		reaction, and ase is	
Workload in Hours		ne in Lecture 28			
Credit points					
Course achievement					
Examination					
Examination duration and	30 min				
scale	Florida Fortes de Contribution	20 de la colonia			
-		Control and Power Systems Engineering: Elective	e compulsory		
rollowing Curricula	Mechatronics: Specialisation intelligen  Mechatronics: Specialisation System D	at Systems and Robotics: Elective Compulsory			
	,	resign: Elective Compulsory n Artificial Organs and Regenerative Medicine: E	Flective Compulsory		
		n Artificial Organs and Regenerative Medicine: E n Implants and Endoprostheses: Elective Compu			
		n Medical Technology and Control Theory: Comp	•		
		n Management and Business Administration: Ele	•		

Course L0660: Linear and No	nlinear System Identification
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<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>

ourses					
itle		Тур	Hrs/wk	СР	
ptimal and Robust Control (L0658	9)	Lecture	2	3	
ptimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Classical control (frequency response, root locus)				
Knowledge	State space methods				
	Linear algebra, singular value decomposition				
Educational Objectives		following learning results			
Educational Objectives Professional Competence	After taking part successfully, students have reached the	following learning results			
Knowledge					
Knowieage	Students can explain the significance of the matrix	Riccati equation for the solution of	LQ problems.		
	They can explain the duality between optimal state	·			
	They can explain how the H2 and H-infinity norms				
	They can explain how an LQG design problem can	·			
	They can explain how model uncertainty can be read on the small gain to				
	<ul> <li>They can explain how - based on the small gain t an uncertain plant.</li> </ul>	neorem - a robust controller can gu	arantee stability	and performance	
	They understand how analysis and synthesis condi	tions on feedback loops can be repr	esented as linear	matrix inequalitie	
	,				
Skills	<ul> <li>Students are capable of designing and tuning LQG</li> </ul>	controllers for multivariable plant m	odels.		
	They are capable of representing a H2 or H-infinity			nd of using stand	
	software tools for solving it.				
	They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loops.				
	sensitivity functions, and of carrying out a mixed-sensitivity design.				
	They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective.				
	robust controller.				
	They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), an				
	<ul> <li>LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust control toolbox).</li> </ul>				
	They can carry out all of the above using standard	software tools (Matiab Tobust Contro	or toolbox).		
Personal Competence					
Social Competence	Students can work in small groups on specific problems t	o arrive at joint solutions.			
Autonomy	Students are able to find required information in sources	provided (lecture notes, literature, s	oftware documer	itation) and use it	
	solve given problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Control and Power S	ystems Engineering: Elective Comp	ulsory		
Following Curricula					
	Aircraft Systems Engineering: Core Qualification: Elective	Compulsory			
	Mechatronics: Specialisation Intelligent Systems and Rob	otics: Elective Compulsory			
	Mechatronics: Specialisation System Design: Elective Cor	npulsory			
	Biomedical Engineering: Specialisation Artificial Organs a	•	Compulsory		
	Biomedical Engineering: Specialisation Implants and Endo				
	Biomedical Engineering: Specialisation Medical Technolog	•	•		
	Biomedical Engineering: Specialisation Management and				
	Product Development, Materials and Production: Specialis	·			
	Product Development, Materials and Production: Specialis Product Development, Materials and Production: Specialis	·	-		
		lective Compulsory	,		

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

Module M0855: Mark	keting (Sales and Services / Innovation Marketing)		
Courses			
Title	Typ Hrs/wk	k CP	
Marketing of Innovations (L2009)		4	
PBL Marketing of Innovations (L086	862) Project-/problem-based Learning 1	2	
Module Responsible	Prof. Christian Lüthje		
Admission Requirements	None		
Recommended Previous			
Knowledge	Module International Business     Basic understanding of business administration principles (strategic planning, decision theorems)	ry project management	
	international business)	ry, project management,	
	Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Ba	asics of Buying Behavior)	
	Unerstanding the differences beweetn B2B and B2C marketing		
	Understanding of the importance of managing innovation in global industrial markets		
	Good English proficiency; presentation skills		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge			
	Specific characteristics in the marketing of innovative poroducts and services  Approaches for applying the current market situation and the future market development.		
	<ul> <li>Approaches for analyzing the current market situation and the future market development</li> <li>The gathering of information about future customer needs and requirements</li> </ul>		
	Concepts and approaches to integrate lead users and their needs into product and service develop	oment processes	
	Approaches and tools for ensuring customer-orientation in the development of new products and in	·	
	Marketing mix elements that take into consideration the specific requirements and challenges of		
	services		
	Pricing methods for new products and services		
	The organization of complex sales forces and personal selling		
	Communication concepts and instruments for new products and services		
Skills	Based on the acquired knowledge students will be able to:		
	Design and to evaluate decisions regarding marketing and innovation strategies		
	Analyze markets by applying market and technology portfolios		
	Conduct forecasts and develop compelling scenarios as a basis for strategic planning		
	Translate customer needs into concepts, prototypes and marketable offers and successfully apply	ly advanced methods for	
	customer-oriented product and service development		
	Use adequate methods to foster efficient diffusion of innovative products and services     Change suitable pricing strategies and communication activities for innovations.		
	<ul> <li>Choose suitable pricing strategies and communication activities for innovations</li> <li>Make strategic sales decisions for products and services (i.e. selection of sales channels)</li> </ul>		
	Apply methods of sales force management (i.e. customer value analysis)		
Personal Competence			
Social Competence	The students will be able to		
	have fruitful discussions and exchange arguments		
	develop original results in a group		
	present results in a clear and concise way		
	carry out respectful team work		
4.4	The state of the state of		
Autonomy	The students will be able to		
	Acquire knowledge independently in the specific context and to map this knowledge on other new	complex problem fields.	
	Consider proposed business actions in the field of marketing and reflect on them.		
Workload in Hours	rs Independent Study Time 110, Study Time in Lecture 70		
Credit points	rs 6		
Course achievement	None		
Examination	n Subject theoretical and practical work		
Examination duration and	d Written elaboration, excercises, presentation, oral participation		
scale	е		
Assignment for the			
Following Curricula			
	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 Implants and Endoprostrieses: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

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

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

Module M1143: Appli	ed Design Methodology in Mechatronics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Med	chatronics (L1523)	Lecture	2	2
Applied Design Methodology in Med	chatronics (L1524)	Project-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
<b>Recommended Previous</b>	Basics of mechanical design, electrical design or computer-sciences			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the foll	owing learning results		
<b>Professional Competence</b>				
Knowledge	Science-based working on interdisciplinary product design co	onsidering targeted application of sp	ecific product	design techniques
Skills	Creative handling of processes used for scientific preparation	and formulation of complex produc	ct design prob	lems / Application o
	various product design techniques following theoretical aspe			, , , , ,
Personal Competence				
Social Competence	Students will solve and execute technical-scientific tasks f	rom an industrial context in small	design-teams	with application of
	common, creative methodologies.			
Autonomy	Students are enabled to optimize the design and developmen	nt process according to the target a	nd topic of the	design
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and	30 min Presentation for a group design-work			
scale				
Assignment for the	International Management and Engineering: Specialisation II.	Product Development and Production	on: Elective Co	ompulsory
Following Curricula	International Management and Engineering: Specialisation II.	Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Pro	duct Development and Production: I	Elective Comp	ulsory
	Mechatronics: Specialisation System Design: Elective Compu	Isory		
	Biomedical Engineering: Specialisation Artificial Organs and F	Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endopro	stheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a	nd Control Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Management and Bus	·	-	
	Theoretical Mechanical Engineering: Specialisation Product D	evelopment and Production: Electiv	e Compulsory	

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>
Literature	<ul> <li>Definition folgt</li> <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: Applied Desig	Course L1524: Applied Design Methodology in Mechatronics	
Тур	Project-/problem-based Learning	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Bioprocess Engineering - Fundamentals (L0841) Lecture 2 3 Bioprocess Engineering - Fundamentals (L0842) Recitation Section (large) 2 1 Bioprocess Engineering - Fundamentals (L0842) Recitation Section (large) 2 2  Module Responsible Prof. Andreas Liese  Admission Requirements None Recommended Previous Knowledge Educational Objectives After taking part successfully, students have reached the following learning results  Professional Competence Knowledge Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry a rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to expl fundamental bioprocess management, sterilization technology and downstream processing in detail.  Skills After successful completion of this module, students should be able to  • describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters • predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on ferementation process • analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations	-				
Deproces Engineering - Fundamentals (L0842)   Pactical Course   2   3	Courses				
Personal Competence   Production   Product	Title				
Module Responsible   Prof. Andreas Lises					
Module Responsible  Admission Requirements  Mono  Recommended Previous  Knowledge  Education Objectives  After taking part successfully, students have reached the following learning results  Professional Competence  Knowledge  After taking part successfully, students have reached the following learning results  Professional Competence  Knowledge  After taking part successfully, students have reached the following learning results  Professional Competence  Knowledge  After successful completion of this module, students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichlometry at metiody can be named and mask transport processes in biomerators can be explained, the students are capable to explained.  After successful completion of this module, students should be able to  describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters  entered translation process  analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations  distinguish between scale-up criteria for different biomerators and bioprocesses (anaerobic, serobic as well as microaerol to compare them as well as to apply then to reutern biotechnological problems  engropses solvions to complicated biotechnological problems and to formulate solutions.  1 to explore new knowledge resources and to apply the newly galined contents  is described and discuss their procedures as well as results in a scientific manner  Personal Competence  Social Competence  After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.  Autonomy  After completion of this module participants will be able to solve a technical problem in					
Recommended Previous one, module "organic chemistry", module "fundamentals for process engineering"  Recommended Previous one, module "organic chemistry", module "fundamentals for process engineering"  Activational Objectives of the training part successfully, students have reached the following learning results  Professional Competence Knowledge  Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics in the concepts of bioprocess engineering. They are able to classify different types of kinetics are concepts of bioprocess engineering. They are able to classify different types of kinetics are concepts of bioprocess engineering. They are able to classify different types of kinetics are concepts of bioprocess engineering. They are able to classify different types of kinetics are concepts of bioprocess in bioreactors can be explained. The students are capable to explained. The students are capable to explain and the concepts of the concepts of the process in bioreactors can be explained. The students are capable to explain and the concepts of the concepts of the process in bioreactors can be explained. The students are capable to explain and the concepts of the concepts of the influence of energy generation, regeneration of redox equivalents are capable to explain and substrate uptake and to calculate the corresponding parameters or predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on fermentation process.  • analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations or distribution and processes on basis of stoichiometry and to set up / solve metabolic flux equations or distribution and to explain a substrate uptake and to definite the corresponding models or compare the rase as well as the concepts and to deduce the corresponding models or compared to explain a substrate uptake and to deduce the corresponding models or to explore new known a		İ	Tractical Course	2	2
Recommended Previous  Knowledge  Educational Objectives  After taking part successfully, students have reached the following learning results  Professional Competence  Knowledge  Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of linibilition. The parameters of stochlometry of theology can be named and mass transport processes in bioprocess of linibilition. The parameters of stochlometry of theology and be named and mass transport processes in bioprocess of linibilition. The parameters of stochlometry of theology and be named and mass transport processes in bioprocess of linibilition. The parameters of stochlometry of theology and downstream processing in defail.  Skills  After successful completion of this module, students should be able to  describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict, qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on fermentation process  analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations  distinguish between scale-up criental for different bioreactors and bioprocesses (nanerobic, aerobic as well as microaerobic to compare them as well as to apply them to current biotechnical problem  propose solutions to complicate biotechnological problems and to deduce the corresponding models  to expire new knowledge resources and to apply the newly gained contents  identification of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.  Autonomy  After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opin					
Educational Objectives  Brofessional Competence  Knowledge  Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry a rheology can be named and mass transport processes in bioresctors can be explained. The students are capable to explication and a state of the students are capable to explication and a state of the students are capable to explication and a state of the students are capable to explication and the students are capable to a students are capable to explication and the students are capable to a complicated blotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents in identify scientific problems with concrete industrial use and to formulate solutions.  Personal Competence  Social Competence  After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.  Autonomy  After com					
Professional Competence  Knowledge Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of kinhibition. The parameters of stoichiometry of meology can be named and mass transport processes in bioreactors can be explained. The students are capable to explore the continual manufacture of the continual process management, sterilization technology and downstream processing in detail.  Skills  After successful completion of this module, students should be able to describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters or predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on fermenatation process  analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations described to compare them as well as to apply then to current biotechnical problem  distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaeroby to complete the corresponding models or to explore new knowledge resources and to apply the newly gained contents  identify scientific problems with concrete industrial use and to formulate solutions.  to explore new knowledge resources and to apply the newly gained contents  identify scientific problems with concrete industrial use and to formulate solutions.  Autonomy  After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their 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 the workflow and to present their results in a plenum.  Examination duration and scientific environments and proce		none, module "organic chemistry", module "	fundamentals for process engineering	]"	
Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of studentians of the clongy can be named and mass transport processes in bioreactors can be explained. The students are capable to explicate the content of the students are capable to explicate the content of the students are capable to explicate the content of the students are capable to explicate the content of the content o	<b>Educational Objectives</b>	After taking part successfully, students have	reached the following learning result	S	
enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry of heology can be named and mass transport processes in bioreactors can be explained. The students are capable to explipation fundamental bioprocess management, sterilization technology and downstream processing in detail.  Skills  After successful completion of this module, students should be able to  • describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters • predict qualitatively the influence of energy generation, regeneration of refox equivalents and growth inhibition on fermentation process • analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations • distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerot to compare them as well as to apply then to current biotechnical problem • propose solutions to complicated biotechnological problems and to deduce the corresponding models • to explore new knowledge resources and to apply the newly gained contents • identify scientific problems with concrete industrial use and to formulate solutions. • to document and discuss their procedures as well as results in a scientific manner  Personal Competence  Social Competence  After completion of this module participants whole able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.  Autanomy  After completion of this module participants will be able to solve a technical problem in a team independently by organizing the workflow and to present their results in a plenum.  Workload in Hours  Credit points  Computery in the procedure of the procedure of the procedure of the process and their procedure of the process of their capacity for teamwork in engineering and scientific environments.  Computery in the proces	<b>Professional Competence</b>				
describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters     predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on fermentation process     analyze bioprocesses on basis of stoichlometry and to set up / solve metabolic flux equations     distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic to compare them as well as to apply them to current biotechnical problem     propose solutions to complicated biotechnological problems and to deduce the corresponding models     to explore new knowledge resources and to apply the newly gained contents     identify scientific problems with concrete industrial use and to formulate solutions.     to document and discuss their procedures as well as results in a scientific manner  Personal Competence  Social Competence  Social Competence  After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their 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 the workflow and to present their results in a plenum.  Workload in Hours  Independent Study Time 96, Study Time in Lecture 84  Credit points  Course achievement  Examination  Written exam  Examination  Examination  Written exam  Examination  Written exam  Examination  General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory  Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory  Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory  Biomedical Engineering: Specialisation III. Engineering Science: Elective Compulsory  Biomedical Engineering: Specialisa		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 are rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain			
Personal Competence  Social Competence After completion of this module participants should be able to debate technical questions in small teams to enhance the ability take position to their own opinions and increase their 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 the workflow and to present their results in a plenum.  Independent Study Time 96, Study Time in Lecture 84  Credit points 6  Compulsory Yes 5 % Subject theoretical and practical work  Examination  Written exam  Examination duration and scale  Assignment for the Following Curricula General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioprocesses: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory	SKIIS	<ul> <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> </ul>			
Credit points 6  Course achievement Yes 5 % Subject theoretical and practical work  Examination duration and scale  Assignment for the Following Curricula General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioprocess Engineeric 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	Social Competence	take position to their own opinions and incre After completion of this module participants	ease their capacity for teamwork in en	gineering and scientific env	ironments.
Credit points 6  Course achievement Yes 5 % Subject theoretical and practical work  Examination Written exam  Examination duration and scale  Assignment for the Following Curricula Bioprocess Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioprocess 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	Workload in Hours	Independent Study Time 96. Study Time in I	ecture 84		
Course achievement Yes 5 % Subject theoretical and practical work  Examination Written exam  Examination duration and scale  Assignment for the Following Curricula 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  Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: 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					
Assignment for the Following Curricula  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 Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective 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		Compulsory Bonus Form Yes 5 % Subject theoretica	·		
Assignment for the Following Curricula  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 Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective 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	Examination	Written exam	<u></u>		
Following Curricula General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective 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		90 min			
Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective 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	Assignment for the			3 3 ,	
Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective 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	Following Curricula			ocess Engineering: Compuls	ory
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					
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		Green Technologies: Energy, Water, Climate	: Specialisation Bioresource Technolog	gy: 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		Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicin	e: Compulsory	
Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Elective Cor	mpulsory	
Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: El	ective Compulsory	
		Biomedical Engineering: Specialisation Mana	gement and Business Administration:	Elective Compulsory	

Course L0841: Bioprocess En	gineering - Fundamentals
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
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>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-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	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012  H. Chmiel: Bioprozeßtechnik, Elsevier, 2006  R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010  H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997  P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess En	gineering- 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
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

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

Courses				
Title		Тур	Hrs/wk	СР
ntroduction to Physiology (L0385)		Lecture	2	3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge	The students can			
	<ul> <li>describe the basics of the energy metabolism;</li> </ul>			
	describe physiological relations in selected fiel	ds of muscle, heart/circulation, r	neuro- and sensory physic	ology.
CI-III-		£		
SKIIIS	The students can describe the effects of basic bodily of forces and vital functions) and relate them to simil		i and processing of infor	nation, developme
Personal Competence	of forces and vital functions) and relate them to simil	ar teermear systems.		
Social Competence	The students can conduct discussions in research and	d medicine on a technical level.		
	The students can find solutions to problems in the fie		and metrological.	
Autonomy	The students can derive answers to questions arising	ig in the course and other phys	siological areas, using te	chnical literature, l
	themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7 se	mester): Specialisation Biomedic	al Engineering: Compulso	ory
Following Curricula	General Engineering Science (German program,	7 semester): Specialisation Me	echanical Engineering, F	ocus Biomechanic
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Techno	logy: Floctive Compulsory		
	Engineering Science: Specialisation Biomedical Engine			
	General Engineering Science (English program, 7		chanical Engineering. F	ocus Biomechanic
	Compulsory		g,	
	General Engineering Science (English program, 7 sen	nester): Specialisation Biomedica	al Engineering: Compulsor	ry
	General Engineering Science (English program, 7 sen	nester): Specialisation Biomedica	al Engineering: Elective Co	ompulsory
	Mechanical Engineering: Specialisation Biomechanics	: Compulsory		
	Biomedical Engineering: Specialisation Medical Techr	ology and Control Theory: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Management			
	Biomedical Engineering: Specialisation Artificial Orga			
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compu	ilsory	
	Technomathematics: Specialisation III. Engineering S			

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

Module M1277: MED I:	: Introduction to Anatomy
Courses	
Title	Typ Hrs/wk CP
Introduction to Anatomy (L0384)	Lecture 2 3
Module Responsible	Prof. Udo Schumacher
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge <sup>*</sup>	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.
Skille	The students can recognize the relationship between given anatomical facts and the development of some common diseases; the
	can explain the relevance of structures and their functions in the context of widespread diseases.
	can explain the relevance of structures and their functions in the context of widespread discuses.
Personal Competence	
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui
,	the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	90 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
•	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	Compulsory
	Data Science: Specialisation Medicine: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory  Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Biomedical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory. Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory

urse L0384: Introduction t	to Anatomy
Тур	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Tobias Lange
Language	
	SoSe General Anatomy
Content	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
	7 <sup>th</sup> week: Genito-urinary System
	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/Michael Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

Module M12/8: MED	l: Introduction to Radiology and Radiation Therapy
Courses	
Title	Typ Hrs/wk CP
Introduction to Radiology and Radia	ation Therapy (L0383) Lecture 2 3
Module Responsible	Prof. Ulrich Carl
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Therapy
	The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).
	The students can describe the patients' passage from their initial admittance through to follow-up care.
	Diagnostics
	The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, a 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 thos techniques.
	The students can choose the right treatment method depending on the patient's clinical history and needs.
	The student can explain the influence of technical errors on the imaging techniques.
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	Therapy
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.
	The students can use the therapeutic principle (effects vs adverse effects)
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of th 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 hel groups, self-help groups, social services, psycho-oncology).
	Diagnostics
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	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 therapeut 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 topi and acquire the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
1	Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

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

Module M1335: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is red	commended.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the fol	lowing learning results		
<b>Professional Competence</b>				
Knowledge	The students can name the different kinds of artificial limbs.			
CI:II-	The short and a second size the second size of seco			
SKIIIS	The students can explain the advantages and disadvantages	s or different kinds of en	doprotneses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to endoproth	ese with student mates	and the teachers.	
Autonomy	The students are able to acquire information on their own. T	hay san also judgo the j	information with respect to	ita aradibility
Autonomy	The students are able to acquire information on their own. I	fley call also judge the i	mormation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Specialisation II	. Process Engineering a	nd Biotechnology: Elective (	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid Materials:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine:	Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopre	ostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a	and Control Theory: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation Management and Bus		lective Compulsory	
	Orientation Studies: Core Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Bio- and	Medical Technology: Ele	ective Compulsory	

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

Module M0845: Feed	back Control in Medical Tech	nology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students ha	ave reached the following learning results		
<b>Professional Competence</b>				
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.		ew. Fundamentals in	
	Internal control loops of the human bod example in for anesthesia control.	y will be discussed in the same way like the	design of external cl	osed loop system fo
	The handling of PID controllers and mod illustrated. The operation of simple equiva	dern controller like predictive controller or fu alent circuits will be discussed.	zzy controller or neu	ral networks will be
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 res	sults	
Autonomy		ture and to set it into the context of the lectur their learning process. They can combine kno		
Workload in Hours	Independent Study Time 62, Study Time i	n Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Med	ical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Cont	trol and Power Systems Engineering: Elective Co	ompulsory	
		plants and Endoprostheses: Elective Compulsor	•	
	Biomedical Engineering: Specialisation Art	tificial Organs and Regenerative Medicine: Elect	ive Compulsory	
		anagement and Business Administration: Electiv		
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Compuls	ory	

Course L0664: Feedback Con	trol in Medical Technology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows:
	<ul> <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> <li>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.</li> </ul>
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 MU832: Adva	nced Topics in Control
Courses	
Title	Typ Hrs/wk CP
Advanced Topics in Control (L0661	L) Lecture 2 3
Advanced Topics in Control (L0662	Recitation Section (small) 2 3
Module Responsible	Prof. Herbert Werner
Admission Requirements	None
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	<ul> <li>Students can explain the advantages and shortcomings of the classical gain scheduling approach</li> <li>They can explain the representation of nonlinear systems in the form of quasi-LPV systems</li> <li>They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions</li> <li>They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems</li> <li>They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniq associated with each of these model structures</li> <li>Students can explain how graph theoretic concepts are used to represent the communication topology of multiag systems</li> <li>They can explain the convergence properties of first order consensus protocols</li> <li>They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models</li> <li>Students can explain concepts behind linear and qLPV Model Predictive Control (MPC)</li> </ul>
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results.
Worldard in House	given problems.  Independent Study Time 124, Study Time in Lecture 56
Workload in Hours  Credit points	
Course achievement	
Examination	
Examination duration and	
scale	
Assignment for the	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
	Mechatronics: Specialisation System Design: 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
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

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

Course L0662: Advanced 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	

	ectromagnetics: Princi				
Courses					
Title			Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and			Lecture	3	5
Bioelectromagnetics: Principles and	1		Recitation Section (small)	2	1
•	Prof. Christian Schuster				
Admission Requirements					
Kecommended Previous  Knowledge	Basic principles of physics				
Educational Objectives	After taking part successfully, st	tudents have reached the follo	wing learning results		
Professional Competence	, , ,		<u> </u>		
•	Students can explain the basic	principles, relationships, and m	ethods of bioelectromagnetics,	i.e. the quantific	ation and applicatio
	of electromagnetic fields in bio	logical tissue. They can define	e and exemplify the most impo	ortant physical ph	nenomena and orde
	them corresponding to wavele	ngth and frequency of the fie	lds. They can give an overvie	w over measure	ment and numerica
	techniques for characterization	of electromagnetic fields in p	practical applications . They ca	n give examples	for therapeutic and
	diagnostic utilization of electron	nagnetic fields in medical tech	nology.		
Skills	Students know how to apply var	rious methods to characterize t	he hehavior of electromagnetic	fields in highgaic	al tissue. In order t
Skills	do this they can relate to and				
	important effects that these m	•	·	-	
	frequency, respectively, and the		•		_
	predictions. They are able to ev	aluate the effects of electroma	gnetic fields for therapeutic an	d diagnostic appli	ications and make a
	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	d of bioelectromagnetics in Eng	ılish.		
	Independent Study Time 110, S	tudy Time in Lecture 70			
Course ashiovement	6 Compulsory Bonus Form	Description			
Course achievement	Yes None Presenta				
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialis	ation Microwave Engineering	Ontics, and Electromagnetic Co	mnatihility: Flecti	ve Compulsory
Following Curricula		-	,	mpanismey. Lietti	ve compaisory
	International Management and			Compulsory	
	Biomedical Engineering: Special	3 3 1	3 3	,	
	Biomedical Engineering: Special			-	
	Biomedical Engineering: Special	lisation Artificial Organs and Re	egenerative Medicine: Elective (	Compulsory	
	Biomedical Engineering: Special	lisation Medical Technology an	d Control Theory: Elective Com	pulsory	
	Theoretical Mechanical Enginee	ring: Specialisation Bio- and Me	edical Technology: Elective Con	npulsory	

Course L0371: Bioelectromagnetics: Principles and Applications		
Тур	Lecture	
Hrs/wk	3	
СР	5	
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle		
Content	- Fundamental properties of electromagnetic fields (phenomena)	
	- Mathematical description of electromagnetic fields (Maxwell's Equations)	
	- Electromagnetic properties of biological tissue	
	- Principles of energy absorption in biological tissue, dosimetry	
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)	
	- Measurement techniques for characterization of electromagnetic fields	
	- Behavior of electromagnetic fields of low frequency in biological tissue	
	- Behavior of electromagnetic fields of medium frequency in biological tissue	
	- Behavior of electromagnetic fields of high frequency in biological tissue	
	- Behavior of electromagnetic fields of very high frequency in biological tissue	
	- Diagnostic applications of electromagnetic fields in medical technology	
	- Therapeutic applications of electromagnetic fields in medical technology	
	- The human body as a generator of electromagnetic fields	
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)	
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)	
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)	
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)	
<u> </u>		

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	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

## Specialization Artificial Organs and Regenerative Medicine

Module M0623: Intelli	igent Systems in Medicine			
C				
Courses		T	Hara faula	CD.
<b>Title</b> Intelligent Systems in Medicine (L0.	331)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Intelligent Systems in Medicine (LO		Project Seminar	2	2
Intelligent Systems in Medicine (LO		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous				
Knowledge	<ul> <li>principles of math (algebra, analysis/calculus)</li> </ul>			
	<ul> <li>principles of stochastics</li> <li>principles of programming, Java/C++ and R/Mat</li> </ul>	lab		
	advanced programming skills	iau		
	autaneed programming skins			
<b>Educational Objectives</b>	After taking part successfully, students have reached t	he following learning results		
<b>Professional Competence</b>				
Knowledge	The students are able to analyze and solve clinical tro			
	optimization, and planning. They are able to explain m			
	in clinical contexts. The students can compare differen		-	
	in the context of clinical data and explain challenges	due to the clinical nature of the data	and its acquisitio	n 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				
•	The students discuss the results of other groups, provi	de helpful feedback and can incoorne	rate feedback into	their work
30ciai Competence	The students discuss the results of other groups, provi	de Helpful feedback and can incoorpo	ate reedback lifto	their work.
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate			
	manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 7	1		
Credit points	6			
Course achievement		cription		
course demovement	Yes 10 % Presentation			
	Yes 10 % Written elaboration			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence Engine	eering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Medical Technology	gy: Elective Compulsory		
	Interdisciplinary Mathematics: Specialisation Computation	• •	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and R			
	Biomedical Engineering: Specialisation Artificial Organs	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and El		1	
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management at			
	Theoretical Mechanical Engineering: Specialisation Bio	- and Medical Technology: Elective Co	ilipuisui y	

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

Course L0333: Intelligent 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

Module M1230: Selec	ted Topics of Biomedical Engineering	J - Option A (6 LP)		
Courses				
Гitle		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	663)	Seminar	2	3
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Following Curricula				
-	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			

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

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

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

Course L1588: Development	Course L1588: Development and Regulatory Approval of Medical Devices		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Clausur		
Examination duration and	90 Minuten		
scale			
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 L0377: Experimental Methods in Biomechanics		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content		
Literature	Wird in der Veranstaltung bekannt gegeben	

Course L1580: Experimental	Methods for the Characterization of Materials
•	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE/EN	
Cycle	SoSe	
Content	<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	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

Trees	Lecture		
Тур	Lecture 2		
Hrs/wk	4		
СР			
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and			
scale			
Lecturer			
Language	DE		
Cycle	WiSe		
Content	Differential equations for momentum-, heat and mass transfer		
	Examples for simplifications of the Navier-Stokes Equations		
	Unsteady momentum transfer		
	Free shear layer, turbulence and free jets		
	Flow around particles - Solids Process Engineering		
	Coupling of momentum and heat transfer - Thermal Process Engineering		
	Rheology – Bioprocess Engineering		
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering		
	Flow threw porous structures - heterogeneous catalysis		
	Pumps and turbines - Energy- and Environmental Process Engineering		
	Wind- and Wave-Turbines - Renewable Energy		
	Introduction into Computational Fluid Dynamics		
Literature	1 December 11 Consultation des Finches and Mahambaranton and Veder Consultation Acres Frankfunt (M) 1071		
	Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.      Brauer, H.: Mayor, D.: Stoffaustrusch einerhälte über handelten Dealting, Frankfurt, Georgiander 1073.      Dealting, Fr		
	<ol> <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> </ol>		
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelber		
	4. Durst, F. Stromangsmechanik. Emilianting in the metric der Stromangen von Platen. Springer-verlag, Berlin, Heidelber 2006.		
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.		
	6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungs		
	Springer Verlag, Berlin, Heidelberg, New York, 2006.		
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GV		
	Fachverlage GmbH, Wiesbaden, 2008.		
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007		
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne		
	GWV Fachverlage GmbH, Wiesbaden, 2009.		
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.		
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring		
	Verlag, Berlin, Heidelberg, 2008.		
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.		
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.		

Course L1820: System Simul	ation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example: Hydraulic systems and heat transfer Example: System with different subsystems	
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>	

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

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

Module M0775: Ergonomics				
Courses				
Title		Тур	Hrs/wk	СР
Ergonomics (L0653)		Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lect	ure 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering: Spe	cialisation II. Product Development an	d Production: Elective Co	ompulsory
Following Curricula	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Elective Compul	sory	
	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Manager	nent and Business Administration: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Electiv	e Compulsory	

Course L0653: Ergonomics	ourse L0653: Ergonomics		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Armin Bossemeyer		
Language	DE		
Cycle	WiSe		
Content			
Literature			

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and (	Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and (		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
<b>Professional Competence</b>				
Skills	(goals, utilities, environments). They can descrican be discussed in terms of decision problem world scenarios, students can summarize how if formalism in static and dynamic settings. In acceptance, with and with complete access to the solving (partially observable) Markov decision Students can identify techniques for simultane desired states. Students can explain coordination of equilibria, social choice functions, voting protections of equilibria, social choice functions, voting protections can derive decision trees and apply be networks/dynamic Bayesian networks and ap different sampling techniques for simplified agreement action or policies for concrete settings. In states, e.g., Nash equilibria. For multi-agent decithe results.	is and algorithms for solving these problems. Bayesian networks can be employed as a know didition, students can define decision making e state of the environment. In this context, such problems, and they can recall techniques for eous localization and mapping, and can explain problems and decision making in a multi-action, and mechanism design techniques.  Solvitecture for concrete agent application scenal asic optimization techniques. For those application ply bayesian reasoning for simple queries, ent scenarios. For simple and complex decision multi-agent situations students will apply techniques.	For dealing with wledge represent procedures in situation to the students can destinate the students can destinate the students rectain the students. For simplifications they can assume that students can also making students for finding the students of t	uncertainty in retation and reason mple and sequen cribe techniques value of informatiniques for achieverm of different typed agent applicated also create Bayes on name and aphts can compute g different equilib
Personal Competence				
Social Competence	Students are able to discuss their solutions to p	roblems with others. They communicate in Eng	glish	
Autonomu	Ctudents are able of sheeking their understandi	ng of compley concents by colving versints of		
Autonomy	Students are able of checking their understandi	ng of complex concepts by solving varaints of		ns
	Students are able of checking their understandi			ns
	Independent Study Time 124, Study Time in Lea			ns
Workload in Hours	Independent Study Time 124, Study Time in Led			ns
Workload in Hours Credit points	Independent Study Time 124, Study Time in Led 6 None			ns
Workload in Hours  Credit points  Course achievement	Independent Study Time 124, Study Time in Led 6 None Written exam			ns
Workload in Hours Credit points Course achievement Examination	Independent Study Time 124, Study Time in Led 6 None Written exam			ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale	Independent Study Time 124, Study Time in Led 6 None Written exam	cture 56		ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Led 6 None Written exam 90 minutes	e Engineering: Elective Compulsory	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the Following Curricula	Independent Study Time 124, Study Time in Led  None Written exam 90 minutes  Computer Science: Specialisation II: Intelligence	e Engineering: Elective Compulsory ecialisation II. Information Technology: Elective	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the Following Curricula	Independent Study Time 124, Study Time in Led  None Written exam 90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Specialisation II: Intelligence International Specialisation Intelligent Systems	e Engineering: Elective Compulsory ecialisation II. Information Technology: Elective e: Elective Compulsory s and Robotics: Elective Compulsory	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the Following Curricula	Independent Study Time 124, Study Time in Led 6 None Written exam 90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Sp. Mechatronics: Technical Complementary Course Mechatronics: Specialisation Intelligent Systems Biomedical Engineering: Specialisation Artificial	e Engineering: Elective Compulsory ecialisation II. Information Technology: Elective e: Elective Compulsory s and Robotics: Elective Compulsory Organs and Regenerative Medicine: Elective C	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the Following Curricula	Independent Study Time 124, Study Time in Led  None Written exam 90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Sp. Mechatronics: Technical Complementary Course Mechatronics: Specialisation Intelligent Systems Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implants	e Engineering: Elective Compulsory ecialisation II. Information Technology: Elective e: Elective Compulsory s and Robotics: Elective Compulsory Organs and Regenerative Medicine: Elective Compulsory	e Compulsory	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the Following Curricula	Independent Study Time 124, Study Time in Led 6 None Written exam 90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Sp. Mechatronics: Technical Complementary Course Mechatronics: Specialisation Intelligent Systems Biomedical Engineering: Specialisation Artificial	e Engineering: Elective Compulsory ecialisation II. Information Technology: Elective e: Elective Compulsory s and Robotics: Elective Compulsory Organs and Regenerative Medicine: Elective Compulsory Technology and Control Theory: Elective Compulsory	e Compulsory	ns

Course L0341: Intelligent Au	tonomous Agents and Cognitive Robotics
	2
	4
	Independent Study Time 92, Study Time in Lecture 28
	Rainer Marrone
-	WiSe
Content	Definition of agents, rational behavior, goals, utilities, environment types
	Adversarial agent cooperation:
	Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of
	chance
	Uncertainty:
	Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product
	rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity,
	independence assumptions, naive Bayes, conditional independence assumptions
	Bayesian networks:
	Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case
	complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly
	perceived).
	Probabilistic reasoning over time:
	Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov
	assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation,
	special cases: hidden Markov models, Kalman filters, Exact inferences and approximations
	Decision making under uncertainty:
	Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio
	Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs
	Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks
	Simultaneous Localization and Mapping     Diagram
	Planning     Carry theory (Calder Balls Calif or Chars)
	Game theory (Golden Balls: Split or Share)  Posicions with multiple agents. Nach aguilibrium. Pougs Nach aguilibrium.
	Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium
	Social Choice  Voting protocols, proforances, paradoves, Arrow's Theorem
	Voting protocols, preferences, paradoxes, Arrow's Theorem,  • Mechanism Design
	Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem,
	Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality
	mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite
	Theorem
	Theorem
Literature	1 Artificial Intelligences A Medera Approach (Third Edition) Charact Description Name - Description Hall 2020 Character 2.5.30
	1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17
	2. Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	2. Fromamilian Nomunics, Hillutt, 3., Burgaru, W., FOX, D. MIT F1855 2003
	3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge
	University Press, 2009
	L

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
-	Students are able to denote terms and concepts of Vil	·	her.	
	Students are able to denote methods of Vibration The	ory and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research ta	sks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	None			
Examination	Written exam			
<b>Examination duration and</b>	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulse	pry		
Following Curricula	International Management and Engineering: Specialisa	·	•	
	Mechanical Engineering and Management: Specialisat	on Mechatronics: Elective Compulsor	ry	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organ	9	re Compulsory	
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Technology	3,	. ,	
	Biomedical Engineering: Specialisation Management a		Compulsory	
	Product Development, Materials and Production: Core			
	Naval Architecture and Ocean Engineering: Core Qual			
	Theoretical Mechanical Engineering: Core Qualification	i: Elective Compulsory		

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

Module M0814: Techr	nology Management			
	lology Planagement			
Courses				
Title		Тур	Hrs/wk	СР
Technology Management (L0849)	((,0050)	Lecture	3	3
Technology Management Seminar		Project-/problem-based Learning	2	3
	Prof. Cornelius Herstatt			
Admission Requirements				
	Bachelor knowledge in business management			
Knowledge	A6-1-1-1			
-	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence	Charles Wards Love College			
Knowledge	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies			
	<ul> <li>Technology Strategies and Lifecycle Manageme</li> </ul>	ent (I/II)		
	<ul> <li>Technology Intelligence and Planning</li> </ul>			
	Technology Portfolio Management			
	<ul> <li>Technology Portfolio Methodology</li> </ul>			
	<ul> <li>Technology Acquisition and Exploitation</li> </ul>			
	IP Management			
	<ul> <li>Organizing Technology Development</li> </ul>			
	<ul> <li>Technology Organization &amp; Management</li> </ul>			
	<ul> <li>Technology Funding &amp; Controlling</li> </ul>			
Skills	The course aims to:			
	<ul> <li>Develop an understanding of the importance of Techn</li> </ul>	ology Management - on a national a	s well as inter	national level
	<ul> <li>Equip students with an understanding of import</li> </ul>	ant elements of Technology Mar	nagement (str	ategic, operational,
	organizational and process-related aspects)			
	<ul> <li>Foster a strategic orientation to problem-solving with</li> </ul>	in the innovation process as well as	s Technology M	Management and its
	importance for corporate strategy			
	<ul> <li>Clarify activities of Technology Management (e.g. technology)</li> </ul>			
	Strengthen essential communication skills and a ba			and financial issues
	concerning Technology-, Innovation- and R&D-manage	ement. Further topics to be discusse	d include:	
	Basic concepts, models and tools, relevant to the man	agement of technology, R&D and in	novation	
	• Innovation as a process (steps, activities and results)			
Personal Competence				
Social Competence				
	Interact within a team			
	Raise awareness for globabl issues			
Autonomy				
	Gain access to knowledge sources	harden and transfer		
	Discuss recent research debates in the context of Tec	nnology and Innovation Managemen	τ	
	<ul> <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				
Course achievement				
Examination	Written exam			
Examination duration and .	90 minutes			
scale	Clabel Innovation Management Comp. C. 175 at			
Assignment for the	•	•		
Following Curricula		•	mpulsory	
	Mechanical Engineering and Management: Specialisation Ma			
	Biomedical Engineering: Specialisation Artificial Organs and I		npulsory	
	Biomedical Engineering: Specialisation Implants and Endopro		an.	
	Biomedical Engineering: Specialisation Medical Technology a		sory	
	Biomedical Engineering: Specialisation Management and Bus	siness Administration: Compulsory		

Course L0849: Technology M	lanagement
Тур	Lecture
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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011

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

n (L0656) n (L0657) Prof. Herbert Werner	<b>Typ</b> Lecture	Hrs/wk	
n (L0657)		Hrs/wk	
		2	<b>CP</b> 4
Prof. Herbert Werner	Recitation Section (small)	2	2
None Introduction to Control Systems			
increased to control systems			
After taking part successfully, students ha	ave reached the following learning results		
Students can explain how linear or response to initial states or externs They can explain the system propestimation, respectively They can explain the significance of they can explain observer-based soon they can explain observer-based soon they can explain the z-transform and they can explain the z-transform and they can explain the z-transform and they can explain the experimental be solved by solving a normal equal to they can explain how a state space.  Students can transform transfer furch they can assess controllability and they can design LQG controllers for they can carry out a controller defor a given sampling rate. They can identify transfer function.	al excitation as trajectories in state space erties controllability and observability, and their of a minimal realisation state feedback and how it can be used to achieve of multi-input multi-output systems and its relationship with the Laplace Transform els and transfer function models of discrete-time station of ARX models of dynamic systems action e model can be constructed from a discrete-time enction models into state space models and vice volumes are multivariable plants are gign both in continuous-time and discrete-time demodels and state space models of dynamic systems are models and state space models of dynamic systems are models and state space models of dynamic systems are models and state space models of dynamic systems.	relationship to state tracking and disturt systems , and how the ident impulse response ersa omain, and decide ms from experimen	e feedback and state  pance rejection  ification problem car  which is appropriate
		entation, experimer	nt guides) and use i
when solving given problems.			
They can assess their knowledge in week	ly on-line tests and thereby control their learning	progress.	
Independent Study Time 124 Study Time	e in Lecture 56		
6			
None			
Written exam			
120 min			
	·		
Computational Science and Engineering: International Management and Engineering International Management and Engineering Mechanical Engineering and Management Mechatronics: Core Qualification: Compul Biomedical Engineering: Specialisation Ar Biomedical Engineering: Specialisation Im Biomedical Engineering: Specialisation M. Biomedical Engineering: Specialisation M. Biomedical Engineering: Specialisation M.	Specialisation II. Engineering Science: Elective Cong: Specialisation II. Electrical Engineering: Electivng: Specialisation II. Mechatronics: Elective Computer: Specialisation Mechatronics: Elective Compulsorsory  tificial Organs and Regenerative Medicine: Electivng plants and Endoprostheses: Elective Compulsory edical Technology and Control Theory: Compulsor anagement and Business Administration: Elective	re Compulsory ulsory ry re Compulsory	
	After taking part successfully, students have a students can explain how linear or response to initial states or extern.  They can explain the system propestimation, respectively  They can explain the significance or they can explain observer-based sorthey can explain observer-based sorthey can explain the z-transform and they can explain the z-transform and they can explain the experimental be solved by solving a normal equal to they can explain how a state space.  Students can transform transfer fure they can design LQG controllers for they can design LQG controllers for a given sampling rate.  They can design LQG controllers for a given sampling rate.  They can identify transfer function.  They can carry out all these task simulink.  Students can work in small groups on specific simulink.  Students can obtain information from pure when solving given problems.  They can assess their knowledge in weeks.  Independent Study Time 124, Study Time for the carry systems: Core Qualification: Elect Aircraft Systems Engineering: Specialisation And Biomedical Engineering: Specialisation Mechanical Engineering: Specialisa	After taking part successfully, students have reached the following learning results  Students can explain how linear dynamic systems are represented as state space response to initial states or external excitation as trajectories in state space  They can explain the system properties controllability and observability, and their estimation, respectively  They can explain observer-based state feedback and how it can be used to achieve they can explain the significance of a minimal realisation  They can explain observer-based state feedback and how it can be used to achieve they can explain the z-transform and its relationship with the Laplace Transform  They can explain the z-transform and its relationship with the Laplace Transform  They can explain the experimental identification of ARX models of discrete-time is be solved by solving a normal equation  They can explain how a state space model and be constructed from a discrete-time is solved by solving a normal equation  They can explain how a state space model can be constructed from a discrete-time in the can explain how a state space model can be constructed from a discrete-time in the can explain how a state space model into state space models and vice were the can explain to a controllers for multivariable plants  They can design LQG controllers for multivariable plants  They can design LQG controllers for multivariable plants  They can identify transfer function models and state space models of dynamic systems. They can identify transfer function models and state space models of dynamic systems. They can carry out all these tasks using standard software tools (Matlab Control Simulink)  Students can work in small groups on specific problems to arrive at joint solutions.  Students can obtain information from provided sources (lecture notes, software docume when solving given problems.  They can assess their knowledge in weekly on-line tests and thereby control their learning Independent Study Time 124, Study Time in Lecture 56  None  Written exam  Telectr	After taking part successfully, students have reached the following learning results  • Students can explain how linear dynamic systems are represented as state space models; they can response to initial states or external excitation as trajectories in state space  • They can explain the system properties controllability and observability, and their relationship to state estimation, respectively  • They can explain the significance of a minimal realisation  • They can explain the significance of a minimal realisation  • They can explain the z-transform and its relationship with the Lapiace Transform  • They can explain the z-transform and its relationship with the Lapiace Transform  • They can explain the z-transform and its relationship with the Lapiace Transform  • They can explain the experimental identification of ARX models of dynamic systems, and how the ident be solved by solving a normal equation  • They can explain the experimental identification of ARX models of dynamic systems, and how the ident be solved by solving a normal equation  • They can explain how a state space model can be constructed from a discrete-time impulse response  • Students can transform transfer function models into state space models and vice versa  • They can design LQG controllers for multivariable plants  • They can carry out a controller design both in continuous-time and discrete-time domain, and decide for a given sampling rate  • They can identify transfer function models and state space models of dynamic systems from experimen  • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System id Simulink)  Students can work in small groups on specific problems to arrive at joint solutions.  Students can obtain information from provided sources (lecture notes, software documentation, experimen when solving given problems.  They can assess their knowledge in weekly on-line tests and thereby control their learning progress.  Independent Study Time 124, Study Time in Lecture 56  6  None  Wri

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

Course L0657: Control Syste	ms 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

ourses				
itle		Тур	Hrs/wk	CP
ne Digital Enterprise (L0932)		Lecture	2	2
oduction Planning and Control (L		Lecture	2	2
Production Planning and Control (L0930)  Exercise: The Digital Enterprise (L0933)		Recitation Section (small)  Recitation Section (small)	1	1 1
		Nectication Section (Smail)	1	
Module Responsible	Prof. Hermann Lödding			
Admission Requirements		h. Managarah		
Kecommended Previous  Knowledge	Fundamentals of Production and Qualit	ту мападетент		
Educational Objectives	After taking part successfully students	s have reached the following learning results		
Professional Competence	Arter taking part successiony, students	s have reached the following learning results		
•	Students can explain the contents of th	he module in detail and take a critical position to them.		
-	· ·	applying models and methods from the module to indu		
Personal Competence	Students are capable of choosing and a	applying models and methods from the module to indu	striai problems.	
•	Students can develop joint solutions in	mixed teams and present them to others.		
Autonomy	Students can develop joint solutions in	mixed teams and present them to others.		
Workload in Hours	Independent Study Time 96, Study Time	ag in Lactura 94		
Credit points		le III Lecture 04		
Course achievement				
	Written exam			
Examination duration and	180 Minuten			
scale	100 Pilliacell			
Assignment for the	International Management and Enginee	ering: Specialisation II. Product Development and Produ	uction: Elective Co	ompulsory
Following Curricula	•	Specialisation Production and Logistics: Elective Compu		,
-	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 Com	pulsory	
	Biomedical Engineering: Specialisation	Management and Business Administration: Compulsor	у	
	Product Development, Materials and Pr	roduction: Specialisation Product Development: Elective	e Compulsory	
	Product Development, Materials and Pr	roduction: Specialisation Production: Compulsory		
	Product Development, Materials and Pr	roduction: Specialisation Materials: Elective Compulsory	y	
	Theoretical Mechanical Engineering: Sr	pecialisation Product Development and Production: Elec	rtive Compulsory	

Course L0932: The Digital En	nterprise
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: Exercise: The	Course L0933: Exercise: The Digital Enterprise		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Axel Friedewald		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	Siehe korrespondierende Vorlesung		
	See interlocking course		

Courses					
Title			Тур	Hrs/wk	CP
Electronic Circuits for Medical Applications (L0696)			Lecture	2	3
Electronic Circuits for Medical Appl			Recitation Section (small)	1	2
Electronic Circuits for Medical Appl			Practical Course	1	1
Module Responsible					
Admission Requirements					
Recommended Previous	Fundamentals of ele	ectrical engineering			
Knowledge					
Educational Objectives	After taking part su	ccessfully, students have rea	ched the following learning results		
Professional Competence Knowledge	Students can     Students are     Students can     Students can     Students can     Students can	able to explain the build-up of exemplify the communication describe the special features explain the functions of pros	ty of the information transfer by the cent of an action potential and its propagation on between neurons and electronic device s of low-noise amplifiers for medical appli theses, e. g. an artificial hand and limitations of cochlea implants and a	along an axon es ications	
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				time.	
Autonomy	necessary. • Students can • Students can	break down their work in ap	the status of their knowledge and to propriate work packages and schedule th uctures of bioelectrical experiments with nanner in all cases and situations of expe	eir work in a realistic	c way.
Workload in Hours	Independent Study	Time 124, Study Time in Lect	ture 56		
Credit points					
Course achievement	Yes None  No None	Form Subject theoretical a practical work Excercises	<b>Description</b> and		
Examination	Written exam	<del></del>			
Examination duration and	90 min				
scale					
Assignment for the	Electrical Engineeri	ng: Specialisation Medical Te	chnology: Elective Compulsory		
Following Curricula	Biomedical Enginee	ring: Specialisation Artificial (	Organs and Regenerative Medicine: Elect	ive Compulsory	
	Biomedical Enginee	ring: Specialisation Implants	and Endoprostheses: Elective Compulsor	у	
	Biomedical Enginee	ring: Specialisation Medical T	echnology and Control Theory: Compulso	ory	
	Biomedical Enginee	ring: Specialisation Managem	nent and Business Administration: Electiv	e Compulsory	
	Microelectronics an	d Microsystems: Specialisatio	n Microelectronics Complements: Electiv	e Compulsory	
	ĺ	ical Engineering: Specialisation			

Course L0696: Electronic Circ	cuits 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

Course L1408: Electronic Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<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/

Module M1150: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534) Recitation Section (small) 2			3	
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g., i	n the module Mechanics II (forces and	d moments, stre	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain en	ergy).		
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to o	alculate the mechanical behavior of n	naterials.	
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions, to present the	nem to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own strengths and problems in the area of continuum mechanics and acqu	·	-	wn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Con	npulsory		
Following Curricula	Mechanical Engineering and Management: Specialisatio	n Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective			
	Biomedical Engineering: Specialisation Artificial Organs	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technolo		-	
	Biomedical Engineering: Specialisation Management and		mpulsory	
	Product Development, Materials and Production: Core Q			
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

Course L1533: Continuum Me	echanics
Тур	Lecture
	2
	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Christian Cyron
Language	
Cycle	WISE
Content	Fundamentals of tensor calculus
	Transformation invariance
	Tensor algebra
	Tensor analysis
	• Kinematics
	Motion of continuum
	<ul> <li>Deformation of infinitesimal line, area and volume elements</li> </ul>
	Material and spatial description
	Polar decomposition
	Spectral decomposition
	Objectivity
	Strain measures
	Time derivatives
	<ul> <li>Partial / material time derivatives</li> </ul>
	<ul> <li>Objective time rates</li> </ul>
	<ul><li>Strain and deformation rates</li></ul>
	Transport theorems
	Balance equations (global and local form)
	Balance of mass
	The stress state
	<ul> <li>Surface traction vectors</li> </ul>
	<ul><li>Cauchy's fundamental theorem</li></ul>
	<ul><li>Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)</li></ul>
	Balance of linear momentum
	Balance of angular momentum
	Balance of energy
	Balance of entropy
	Clausius-Duhem inequality
	Constitutive laws
	<ul><li>Constitutive assumptions</li><li>Fluids</li></ul>
	<ul><li>Elastic solids</li><li>Hyperelasticity</li></ul>
	Material symmetry
	Elasto-plastic solids
	Analysis
	Initial-boundary value problems and their numerical solution
	and a control of the
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
Electature	
	I-S. Liu: Continuum Mechanics, Springer
	weitere siehe in der Literaturliste des Scripts

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		

Module M1151: Mate	rials Modeling
Courses	
Title	Typ Hrs/wk CP
Material Modeling (L1535)	Lecture 2 3
Material Modeling (L1536)	Recitation Section (small) 2 3
Module Responsible	Prof. Christian Cyron
Admission Requirements	None
<b>Recommended Previous</b>	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (for
Knowledge	and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)
Educational Objectives	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowled
	to various problems of material science and evaluate the corresponding material models.
Personal Competence	
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and so
	problems in the area of materials modeling and acquire the knowledge required to this end.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	
Examination	
Examination duration and scale	
Assignment for the	
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory  Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Product Development, Materials and Production: Core Qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

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

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

Module M1199: Adva	nced Functional Materials
Courses	
Title	Typ Hrs/wk CP
Advanced Functional Materials (L16	625) Seminar 2 6
Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particul
	metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design ne
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview of
	modern materials science, which enables them to select optimum materials combinations depending on the technic
	applications.
Personal Competence	
	The students are able to present solutions to specialists and to develop ideas further.
Jocial Competence	The stadents are able to present solutions to specialists and to develop ideas further.
Autonomy	The students are able to
	assess their own strengths and weaknesses.
	gather new necessary expertise by their own.
Workload in Hours	
Credit points	
Course achievement	
Examination	
Examination duration and	
scale	
Assignment for the Following Curricula	
i ollowing 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
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	anics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
•				
	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsorv	

Course L1663: Nature's Hiera	archical Materials
	Seminar
Hrs/wk	
CP	
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	
СР	
Workload in Hours	
Examination Form	
Examination duration and	
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagatic 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 - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

Course L1588: Development and Regulatory Approval of Medical Devices		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Roman Nassutt	
Language	DE	
Cycle	WiSe	
Content		
Literature	<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 L0377: Experimental Methods in Biomechanics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental	Methods for the Characterization of Materials
-	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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 Biom	Course L1890: Seminar Biomedical Engineering		
Тур	eminar		
Hrs/wk	2		
СР	3		
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28		
Examination Form	eferat		
Examination duration and	rhriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

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

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

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

Course L0379: Ceramics Tecl	hnology		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Stu	udy Time in Lecture 28	
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
	Dr. Rolf Janßen		
Language			
Cycle		sing 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: Inhalt:	Introduction     Raw materials	
	Titlate.		
	3. Powder fabrication		
		4. Powder processing	
		5. Shape-forming processes	
		6. Densification, sintering	
		7. Glass and Cement technology	
	8. Ceramic-metal joining techniques		
Literature	W.D. Kingery, "Introduction to C	eramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials Hand	dbook Vol.4 "Ceramics and Glasses", 1991	
	D.W. Richerson, "Modern Ceramic Engineering", Marcel Decker, New York, 1992		
	Skript zur Vorlesung		

Module M1279: MED	I: Introduction to Biochemis	stry and Molecular Biology	
Courses			
Title		Тур	Hrs/wk CP
Introduction to Biochemistry and M	olecular Biology (L0386)	Lecture	2 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students h	nave reached the following learning results	
<b>Professional Competence</b>			
Knowledge	The students can		
	<ul> <li>describe basic biomolecules;</li> </ul>		
	<ul> <li>explain how genetic information is</li> </ul>	s coded in the DNA;	
	explain the connection between D	DNA and proteins;	
CI:II-	The about substants		
SKIIIS	The students can		
	<ul> <li>recognize the importance of mole</li> </ul>	cular parameters for the course of a disease;	
	<ul> <li>describe selected molecular-diagr</li> </ul>	nostic procedures;	
	<ul> <li>explain the relevance of these pro</li> </ul>	ocedures for some diseases	
Personal Competence			
	The students can participate in discussion	ons in research and medicine on a technical lev	el.
Autonomy	The students can develop understanding	g of topics from the course, using technical liter	rature, by themselves.
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28	
Credit points			
Course achievement	None		
Examination	Written exam		
Examination duration and	60 minutes		
scale			
Assignment for the	General Engineering Science (German p	rogram, 7 semester): Specialisation Biomedical	Engineering: Compulsory
Following Curricula	General Engineering Science (German	n program, 7 semester): Specialisation Mecl	hanical Engineering, Focus Biomechai
	Compulsory		
	Data Science: Specialisation Medicine: C	Compulsory	
	Electrical Engineering: Specialisation Me	dical Technology: Elective Compulsory	
	Engineering Science: Specialisation Bion	nedical Engineering: Compulsory	
	General Engineering Science (English pr	ogram, 7 semester): Specialisation Biomedical	Engineering: Compulsory
	General Engineering Science (English	program, 7 semester): Specialisation Mech	hanical Engineering, Focus Biomecha
	Compulsory		
	Mechanical Engineering: Specialisation E	Biomechanics: Compulsory	
		Management and Business Administration: Elect	
		Artificial Organs and Regenerative Medicine: Ele	, ,
		Medical Technology and Control Theory: Elective	
		mplants and Endoprostheses: Elective Compuls	ory
	rechnomathematics: Specialisation III. E	ngineering Science: Elective Compulsory	

Course I 0386: Introduction t	to Biochemistry and Molecular Biology	
	Lecture Lecture	
Hrs/wk		
CP		
	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Hans-Jürgen Kreienkamp	
Language	DE	
Cycle	ViSe	
Content		
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage	
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008	

Module M1334: BIO II	: Biomaterials		
Courses			
Title	Typ Hrs/wk CP		
Biomaterials (L0593)	Lecture 2 3		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is recommended.		
Knowledge			
<b>Educational Objectives</b>	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 or 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	90 min		
scale			
Assignment for the	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory		
Following Curricula	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: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0593: Biomaterials	<u> </u>		
Typ	Lecture		
Hrs/wk			
	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language	EN		
Cycle	WiSe		
Content	Topics to be covered include:		
	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		
	.4 Ligaments		
	3.5 Tendons		
	3.6 Skin		
	3.7 Nervs		
	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.		
1 5k	Hastings C and Duchovno B - Natural and living hismostopials Reco Rates CRC Pro 1994		
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.		
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.		
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.		
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.		
	Wintermantel, E. und Ha, SW: Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.		

	Elements Methods			
Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge overview of the theoretical and methodical bas		ent method and	are able to give
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the correspondin system matrices, and solving the resulting system of equations.			
Personal Competence Social Competence	Students can work in small groups on specific	problems to arrive at joint solutions.		
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element routine Problems can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Compulso	ory		
Following Curricula	Energy Systems: Core Qualification: Elective Co	ompulsory		
	Aircraft Systems Engineering: Specialisation Ai	rcraft Systems: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation Ai	r Transportation Systems: Elective Compulsory		
	Aircraft Systems Engineering: Core Qualificatio	n: Elective Compulsory		
	International Management and Engineering: Sp	pecialisation II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering: Sp	pecialisation II. Product Development and Produ	uction: Elective Co	ompulsory
	Mechatronics: Core Qualification: Compulsory	·		
	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Manage	' ' '	mpulsory	
	Biomedical Engineering: Specialisation Medical			
	Biomedical Engineering: Specialisation Artificia	•	-	
	Product Development, Materials and Productio	· ·		
	Technomathematics: Specialisation III. Enginee			

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

Course L0804: Finite Elemen	ourse L0804: Finite Element Methods		
Тур	ecitation Section (large)		
Hrs/wk			
СР			
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28		
Lecturer	f. Otto von Estorff		
Language			
Cycle	iSe		
Content	ee interlocking course		
Literature	ee interlocking course		

Title Title Typ Mrs/will Structure and Properties of Polymers (L0389) Lecture 2 Processing and design with polymers (L0389) Lecture 2 Module Responsible Dr. Hans Wittich  Admission Requirements None Recommended Previous Knowledge Basics: chemistry / physics / material science Knowledge Educational Objectives 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 neighboring contexts (e.g. sus protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical properties (modulus, st evaluate the different materials selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic Personal Competence Social Competence Social Competence - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic Personal Competence - 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 possible consequences of their professional activity.  Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Credit points 6 Course achievement None  Examination Written exam  Examination duration and scale  Assignment for the Following Curricula Biomedical Engineering: Specialisation Implanering Materials: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Ma		
Structure and Properties of Polymers (L0389) Processing and design with polymers (L1892)  Module Responsible  Private Processing and design with polymers (L1892)  Module Responsible  Professional Competence  Knowledge  Educational Objectives  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. sus protection).  Skills  Students are capable of  - using standardized calculation methods in a given context to mechanical properties (modulus, st evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic evaluate the different materials.  - selecting appropriate feedback and handle feedback on their own performance constructively.  Personal Competence  Social Competence  Social Competence  Social Competence  Social Competence  Students are able to  - assess their own strengths and weaknesses.  - 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 beside consequences of their professional activity.  Morkload in Hours  Course achievement  None  Examination  Examination  Examination  Written exam  Bloomin  Secale  Assignment for the Following Curricule  Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: S		
Module Responsible   Dr. Hans Wittich   Admission Requirements   None   Basics: chemistry / physics / material science   Recommended Previous   Knowledge   Basics: chemistry / physics / material science   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. sus protection).   Skills   Students are capable of   using standardized calculation methods in a given context to mechanical properties (modulus, steelulate the different materials.   selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic   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 stengths and weaknesses   assess their own strengths and seale   Samination   Sa	wk	CP
Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives 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. sus protection).  Skills Students are capable of  using standardized calculation methods in a given context to mechanical properties (modulus, stevaluate the different materials. selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosic science Social Competence Competence Social C		3
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Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	•	
Product Development, Materials and Production, Specialisation Production, Elective Compulsors		
Product Development, Materials and Production: Specialisation Materials: Elective Compulsory		
Product Development, Materials and Production: Specialisation Product Development: Elective Compulsor  Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	ory	

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

Course L1892: Processing and design with polymers		
Тур	Lecture	
Hrs/wk	2	
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: Rege	nerative Medicir	ne			
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347)			Seminar	2	3
Lecture Tissue Engineering - Reger	nerative Medicine (L1664)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
<b>Educational Objectives</b>	After taking part succe	essfully, students have re	ached the following learning results		
<b>Professional Competence</b>					
Knowledge	·		dents will be able to describe the basic	-	
	the cultivation of anima		nethods of tissue engineering. They are a	ble to give a basic ov	erview of methods fo
		tline the actual concept of the discussed topics.	s of Tissue Engineering and regenerat	ive medicine and ca	an explain the basi
Skills	After successful compl	letion of the module stude	ents are		
	able to present to able to carry out	their work results in the f t basic cell culture metho	erung and presentation of relevant up-to orm of presentations ds and the corresponding analysis indepe earch topics for Tissue Engineering and re	endently	
Personal Competence Social Competence	Students are able to w defend them.		rith 2-4 students to solve given tasks and		in the plenary and t
Autonomy	*	this module, participants	s will be able to solve a technical proposelts.	oblem in teams of	approx. 2-4 person
Workload in Hours	Independent Study Tim	ne 124, Study Time in Lec	cture 56		
Credit points					
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / prot	ocol for lecture series	
Examination	Presentation				
<b>Examination duration and</b>	Oral presentation + dis	scussion (30 min)			
scale					
Assignment for the	Biomedical Engineering	g: Specialisation Implants	and Endoprostheses: Elective Compulso	ry	
Following Curricula	Biomedical Engineering	g: Specialisation Artificial	Organs and Regenerative Medicine: Com	pulsory	
	Biomedical Engineering	g: Specialisation Manage	ment and Business Administration: Electiv	e Compulsory	
	Biomedical Engineering	g: Specialisation Medical	Technology and Control Theory: Elective	Compulsory	

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

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	

Module M1333: BIO I:	Implants and Fracture Healing
Courses	
Title	Typ Hrs/wk CP
Implants and Fracture Healing (L03	176) Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.
Clille	
SKIIIS	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
Personal Competence	
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	90 min
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechar
Following Curricula	Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechar
	Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	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 Compulsory
	Orientation Studies: Core Qualification: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0376: Implants and	Fracture Healing	
Тур	Lecture	
Hrs/wk		
СР		
	Independent Study Time 62, Study Time in Lecture 28	
Language	Prof. Michael Morlock DE	
Cycle		
Content	Topics to be covered include:	
	Introduction (history, definitions, background importance)	
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)	
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)	
	3.1 The spine in its entirety	
	3.2 Cervical spine	
	3.3 Thoracic spine	
	3.4 Lumbar spine	
	3.5 Injuries and diseases	
	4. Pelvis (anatomy, biomechanics, fracture treatment)	
	5 Fracture Healing	
	5.1 Basics and biology of fracture repair	
	5.2 Clinical principals and terminology of fracture treatment	
	5.3 Biomechanics of fracture treatment	
	5.3.1 Screws	
	5.3.2 Plates	
	5.3.3 Nails	
	5.3.4 External fixation devices	
	5.3.5 Spine implants	
	6.0 New Implants	
Literature	Cochran V.B.: Orthopädische Biomechanik	
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics	
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine	
	Nigg, B.: Biomechanics of the musculo-skeletal system	
	Schiebler T.H., Schmidt W.: Anatomie	
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat	

	<u></u>	<u></u>				
Courses						
Title			7	Гур	Hrs/wk	СР
Microsystems Technology (L0724)				Lecture	2	4
Microsystems Technology (L0725)	T		F	Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous	Basics in physics, che	mistry, mechanics and s	emiconductor techno	ology		
Knowledge						
Educational Objectives	After taking part succ	essfully, students have r	eached the following	g learning results		
Professional Competence	Charleste ene elle					
Knowieage	Students are able					
	·	·	·	or microstructures and especia of in more complex systems	illy methods fo	or the fabrication o
	to explain in deta	ils operation principles o	f microsensors and r	microactuators and		
	to discuss the pot	tential and limitation of r	nicrosystems in appl	lication.		
Skills	Students are capable					
	to analyze the feature.	asibility of microsystems	,			
	to develop proces	ss flows for the fabrication	on of microstructures	s and		
	to apply them.					
Personal Competence Social Competence	Students are able to p	orepare and perform the	ir lab experiments ir	n team work as well as to preso	ent and discuss	s the results in fror
Autonomy	None					
Workload in Hours		me 124, Study Time in L	ecture 56			
Credit points		Form	Description			
Course achievement	Yes None	Subject theoretical practical work	andStudierenden f	führen in Kleingruppen ein La d diskutiert die Theorie sowie o nten Kurs.	•	
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the	Electrical Engineering	: Specialisation Nanoele	ctronics and Microsy	stems Technology: Elective Co	mpulsory	
Following Curricula	3	: Specialisation Medical				
	_			natronics: Elective Compulsory		
	_		·	ses: Elective Compulsory		
	Biomedical Engineering	ng: Specialisation Medica	I Technology and Co	ontrol Theory: Elective Compuls		
	B1 11 1 - 1					
	_			Administration: Elective Comp nerative Medicine: Elective Com	-	

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-general lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering: 0 techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etch anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop technique plasma processes, dry etching: back sputtering, plasma etching, film stress, stiction: texpy and counter measu Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SUB, rapid prototyping)</li> <li>Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermory modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemone mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure senspiezoresistive, capacitive and fabrication process;</li> <li>Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresis sensors: magneto resistance, AMR and GMR, fluxgate magnetometer)</li> <li>Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosen Clark electrode, enzyme electrode, DNA chip)</li> <li>Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulat DMD, adaptive optics, mic</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

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

Module M0630: Robot	tics and Naviga	ation in Med	icine			
Courses						
Title				Тур	Hrs/wk	СР
Robotics and Navigation in Medicin Robotics and Navigation in Medicin				Lecture Project Seminar	2	3 2
Robotics and Navigation in Medicin				Recitation Section (small)	1	1
Module Responsible		aefer		,		
Admission Requirements	None					
Recommended Previous						
Knowledge		nath (algebra, ana				
		rogramming, e.g.,	in Java or C++			
	solid R or Matl	ab skills				
<b>Educational Objectives</b>	After taking part succ	cessfully, students	have reached the follo	owing learning results		
<b>Professional Competence</b>						
Knowledge	The students can ex	plain kinematics	and tracking systems	in clinical contexts and illustra	ate systems and	their components in
				detection and safety and reg	ulations. Student	s can assess typical
	systems regarding de	esign and limitati	ons.			
Skills	The students are able	e to design and ev	valuate navigation syst	ems and robotic systems for me	dical applications	i.
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 ref	lect their knowled	dge and document the	results of their work. They can	nresent the resu	Ilts in an annronriate
, iaconomy	manner.	Teet then knowned	age and accument the	results of their morni riney can	present the rese	an appropriate
Workload in Hours	Independent Study T	ime 110. Study Ti	me in Lecture 70			
Credit points		inc 110, Study 11	THE III ECCLUTE 70			
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Presentation				
	Yes 10 %	Written elabora	tion			
Examination	Written exam					
Examination duration and	90 minutes					
scale						
•	·	•				
Following Curricula						
	-	_		•		C
	_				nnology: Elective	Compulsory
	· ·				Compulsory	
	3	J 1	9	3	Compuisory	
	3	J .		nd Control Theory: Elective Com	pulsory	
	3	J .	3,	iness Administration: Elective Co		
	_			on Product Development: Electiv		
	-			on Production: Elective Compuls		
	Product Developmen	t, Materials and P	roduction: Specialisatio	on Materials: Elective Compulsor	у	
	Theoretical Mechanic	al Engineering: S	pecialisation Bio- and N	Medical Technology: Elective Cor	npulsory	
scale Assignment for the Following Curricula	Electrical Engineering International Manage International Manage Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen Product Developmen	g: Specialisation Mement and Engine ment and Engine specialisation ment and Engine specialisation to Materials and Pt, Materials and Pt, Materials and Pt, Materials and Pt,	ering: Specialisation II. t Systems and Robotics Artificial Organs and F Implants and Endopro Medical Technology a Management and Bus roduction: Specialisatic roduction: Specialisatic	Ective Compulsory Electrical Engineering: Elective Process Engineering and Biotects: Elective Compulsory Regenerative Medicine: Elective stheses: Elective Compulsory and Control Theory: Elective Com iness Administration: Elective Com product Development: Elective production: Elective Compulsory and Materials: Elective Compulsory and Materials: Elective Compulsory	hnology: Elective  Compulsory  pulsory  ompulsory  e Compulsory  ory  y	Compulsory

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

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

Course L0336: Robotics and 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	

Module M1384: Case	Studies for Regenerative Med	icine and Tissue Engineering		
Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	e reached the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: Com	pulsory	
Following Curricula	Biomedical Engineering: Specialisation Impla	' '	,	
		agement and Business Administration: Electiv		
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective	Compulsory	

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

Module M0634: Introd	luction into Me	edical Technology	and Systems		
Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical Technolog	y and Systems (L0342)		Lecture	2	3
Introduction into Medical Technolog	gy and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technolog	y and Systems (L1876)		Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schla	efer			
Admission Requirements	None				
<b>Recommended Previous</b>	principles of math (al	gebra, analysis/calculus)			
Knowledge	principles of stochas	tics			
	principles of program	ming, R/Matlab			
Educational Objectives	After taking part succ	cessfully, students have rea	ched the following learning results		
Professional Competence	• •	· · · · · · · · · · · · · · · · · · ·			
•	The students can ex	xplain principles of medica	I technology, including imaging systems,	computer aided s	surgery, and medical
-			verview of regulatory affairs and standards		
Skills	The students are able	e to evaluate systems and	nedical devices in the context of clinical ap	plications.	
Personal Competence					
Social Competence	The students describe	e a problem in medical tecl	nnology as a project, and define tasks that a	are solved in a join	t effort.
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 Ti	ime 110, Study Time in Lec	ture 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination	Written exam				
Examination duration and	90 minutes				
scale					
Assignment for the	General Engineering	Science (German program,	7 semester): Specialisation Biomedical Eng	gineering: Compuls	ory
Following Curricula		·	Software Engineering: Elective Compulsory		
			s and Engineering Science: Elective Compu	lsory	
		ualification: Elective Comp	•		
		g: Core Qualification: Electi			
		Specialisation Biomedical			
			7 semester): Specialisation Biomedical Engi		
			isation II. Mathematics & Engineering Scier	·	uisory
	_		Organs and Regenerative Medicine: Elective	e compuisory	
	_		and Endoprostheses: Elective Compulsory Technology and Control Theory: Elective Co	maulaani	
		nu. precialisation Medical			
	_		nent and Business Administration: Elective		

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calaulua			
Knowledge	Calculus     Linear Algebra			
	<ul><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>			
	• Engineering Mechanics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the	ne following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able to reflect existing terms and conce	epts in Nonlinear Dynamics and to	develop and resea	arch new terms and
	concepts.			
Skills	Students are able to apply existing methods and proces	sures of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks ind	vidually and to identify and follow u	ıp novel research ta	sks by themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Electiv	e Compulsory		
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	n Mechatronics: Elective Compulsor	У	
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and Ro			
	Biomedical Engineering: Specialisation Artificial Organs	•	e Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	•		
	Biomedical Engineering: Specialisation Management an		Compulsory	
	Product Development, Materials and Production: Core C	' '		
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

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

ourses				
		Turn	Han hade	CD
<b>tle</b> miconductor Technology (L0722)		<b>Typ</b> Lecture	Hrs/wk 4	<b>CP</b> 4
miconductor Technology (L0723)		Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science a	nd semiconductor devices		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have re-	ached the following learning results		
<b>Professional Competence</b>				
Knowledge				
	Students are able			
	Students are able			
	to describe and to explain current fabrication	on techniques for Si and GaAs substrates,		
	to discuss in details the relevant fab.	rication processes, process flows and t	he impact thereof o	n the fabrication
	semiconductor devices and integrated circuits a	·	ine impact thereof o	ii tile labileation
	<ul> <li>to present integrated process flows.</li> </ul>			
Skills				
	Students are capable			
	• to analyze the impact of process paramete	rs on the processing results		
	to analyze the impact of process paramete	is on the processing results,		
	to select and to evaluate processes and			
	to develop process flows for the fabrication	of semiconductor devices		
	to develop process none to the tustication	e. se.mesnaacto. aevices.		
Personal Competence				
Social Competence				
,				
	Students are able to prepare and perform their	lab experiments in team work as well as	to present and discus	ss the results in fr
	of audience.			
Autonomy	None			
	Independent Study Time 96, Study Time in Lect	ure 84		
Credit points		uic 04		
Course achievement				
Examination	Oral exam			
Examination duration and				
scale	· · · · · · ·			
Assignment for the	Electrical Engineering: Specialisation Nanoelect			
Following Curricula	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Manage	,		
	biomedical Engineering: Specialisation Manage	ment and business Administration: Elective	ve compuisory	

	or Technology
Тур	Lecture
Hrs/wk	4
Orkload in Hours	4 Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
Cycle	
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, hig order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dama annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinet influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs)</li> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinet</li> </ul>
	<ul> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kineti temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacua evaporation, sputtering)</li> </ul>
	<ul> <li>Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxim and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique a electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, elect beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic a anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchi backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> </ul>
	Process integration (CMOS process, bipolar process)
	<ul> <li>Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical conti wire bonding, TAB and flip chip, wafer level package, 3D stacking)</li> </ul>
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	3. Campbell. The Science and Engineering of Microelectronic rabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
<b>Admission Requirements</b>	None			
<b>Recommended Previous</b>				
Knowledge	Introduction to control systems			
	Control theory and design			
<b>Educational Objectives</b>	After taking part successfully, students have re-	ached the following learning results		
<b>Professional Competence</b>				
Knowledge	<ul> <li>Students can explain humanoid robots.</li> </ul>			
	Students learn to apply basic control con	cepts for different tasks in humanoid ro	obotics.	
	,	•		
Skills	Students acquire knowledge about select	ted aspects of humanoid robotics, base	d on specified literature	
	Students generalize developed results ar	nd present them to the participants		
	Students practice to prepare and give a d give a prepare and give a give a prepare and give a gi	oresentation		
Personal Competence				
Social Competence				
Social Competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	They are able to provide appropriate feed	dback and handle constructive criticism	n of their own results	
Autonomy				
,	<ul> <li>Students evaluate advantages and drag</li> </ul>	wbacks of different forms of presenta	ation for specific tasks	and select the bes
	solution			
	Students familiarize themselves with a state of the		and follow presentation	ns of other students
	such that a scientific discussion develops	•		
Workload in Hours	Independent Study Time 32, Study Time in Lect	ure 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems	, ,		
Following Curricula	Mechatronics: Specialisation System Design: Ele			
	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Implants	·	•	
	Biomedical Engineering: Specialisation Medical	•		
	Biomedical Engineering: Specialisation Manager Theoretical Mechanical Engineering: Specialisat			
	Theoretical Mechanical Engineering: Specialisat	ion Nobolics and Computer Science: El	ective Compuisory	

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

Module M0838: Linea	r and Nonlinear System Id	entifikation		
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Ident	ification (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	0			
Knowledge	Classical control (frequency responses)	ponse, root locus)		
	<ul><li>State space methods</li><li>Discrete-time systems</li></ul>			
	Linear algebra, singular value d	ecomposition		
	Basic knowledge about stochast			
<b>Educational Objectives</b>	After taking part successfully, students	s have reached the following learning results		
<b>Professional Competence</b>				
Knowledge		ral framework of the prediction error method a	and its application to a	variety of linear and
	nonlinear model structures	rai namework of the prediction error method a	na its application to a	variety of infear and
		r perceptron networks are used to model nonline	ear dynamics	
		ximate predictive control scheme can be based of	•	ls
	They can explain the idea of sul	bspace identification and its relation to Kalman r	ealisation theory	
Skills		ing the predicition error method to the experin	nental identification of	linear and nonlinea
	models for dynamic systems			
	They are capable of implementing a nonlinear predictive control scheme based on a neural network model			
	• They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems			
	They can do the above using sta	andard software tools (including the Matlab Syst	em Identification Toolbo	x)
Personal Competence				
	Students can work in mixed groups on	specific problems to arrive at joint solutions.		
Autonomy	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 62, Study Tin	ne in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
<b>Examination duration and</b>	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation C	Control and Power Systems Engineering: Elective	Compulsory	
Following Curricula	Mechatronics: Specialisation Intelligen	t Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System D	Design: Elective Compulsory		
		Artificial Organs and Regenerative Medicine: Ele		
		Implants and Endoprostheses: Elective Compuls		
		Medical Technology and Control Theory: Compu		
		Management and Business Administration: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: C	ore Qualification: Elective Compulsory		

Course L0660: Linear and No	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>				

vodule M0840: Optin	nal and Robust Control				
ourses					
itle		Тур	Hrs/wk	СР	
ptimal and Robust Control (L0658		Lecture	2	3	
ptimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	<ul> <li>Classical control (frequency response, root I</li> </ul>	ocus)			
Knowledge	State space methods				
	Linear algebra, singular value decomposition	n			
Educational Objectives	After taking part successfully, students have reach	ned the following learning results			
Professional Competence	The calling part succession, y stade his have reach	ica the femological mig results			
Knowledge					
	Students can explain the significance of the				
	They can explain the duality between optim	·			
	They can explain how the H2 and H-infinity				
	They can explain how an LQG design proble  They can explain how mandal uncombinety and the second states are second sometimes.	•			
	They can explain how model uncertainty can     They can explain how based on the small	,		-	
	<ul> <li>They can explain how - based on the small an uncertain plant.</li> </ul>	gain theorem - a robust controller can gu	larantee stability	and performance	
	They understand how analysis and synthesis	s conditions on feedback loops can be repr	esented as linear	matrix inequalitie	
		·		•	
Skills	<ul> <li>Students are capable of designing and tunin</li> </ul>	ng LQG controllers for multivariable plant m	nodels.		
	They are capable of representing a H2 or H-			nd of using standa	
	software tools for solving it.				
	<ul> <li>They are capable of translating time and fr</li> </ul>	requency domain specifications for contro	l loops into const	raints on closed-lo	
	sensitivity functions, and of carrying out a mixed-sensitivity design.				
	They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective.				
robust controller.					
	<ul> <li>They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of usi LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust control toolbox).</li> </ul>				
	They can carry out an of the above using ste	andard software tools (Matlab Tobust Conti-	or toolbox).		
Personal Competence					
Social Competence	Students can work in small groups on specific prob	plems to arrive at joint solutions.			
Autonomy	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it				
	solve given problems.				
Washing die Hause	Indiana destruction 124 Study Time in Land	FC			
Workload in Hours  Credit points	Independent Study Time 124, Study Time in Lectur	re 56			
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Australia de Caralla			To a second		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and F	, , , ,	ulsory		
Following Curricula	Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Core Qualification: E	,			
	Mechatronics: Specialisation Intelligent Systems ar				
	Mechatronics: Specialisation System Design: Electi	' '			
	Biomedical Engineering: Specialisation Artificial Or		Compulsory		
	Biomedical Engineering: Specialisation Implants ar	•	. ,		
	Biomedical Engineering: Specialisation Medical Tec		pulsory		
	Biomedical Engineering: Specialisation Manageme	nt and Business Administration: Elective Co	ompulsory		
	Product Development, Materials and Production: S	pecialisation Product Development: Electiv	e Compulsory		
	Product Development, Materials and Production: S	·	•		
	Product Development, Materials and Production: S		ТУ		
	Theoretical Mechanical Engineering: Core Qualifica	ation: Elective Compulsory			

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

Module M0855: Marko	eting (Sales and Services / Innovation I	Marketing)		
Courses				
Title		Тур	Hrs/wk	СР
Marketing of Innovations (L2009)		Lecture	4	4
PBL Marketing of Innovations (L086	52)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements				
Recommended Previous	<ul> <li>Module International Business</li> </ul>			
Knowledge	Basic understanding of business administration	principles (strategic planning, decision	on theory, pro	oject management,
	international business)			
	Bachelor-level Marketing Knowledge (Marketing In		egies, Basics o	f Buying Behavior)
	Unerstanding the differences beweetn B2B and B2     Understanding of the discount of the			
	<ul> <li>Understanding of the importance of managing inno</li> <li>Good English proficiency; presentation skills</li> </ul>	ovacion in global mouscrial markets		
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innoval	tive poroducts and services		
	Approaches for analyzing the current market situa	tion and the future market development	i	
	The gathering of information about future custome			
	Concepts and approaches to integrate lead users a			
	<ul> <li>Approaches and tools for ensuring customer-orient</li> <li>Marketing mix elements that take into consideral</li> </ul>			
	services	speeme requirements and endi-	anges or mile	racive produces and
	Pricing methods for new products and services			
	The organization of complex sales forces and pers	onal selling		
	Communication concepts and instruments for new	products and services		
Skills	Based on the acquired knowledge students will be able to	o:		
	Design and to evaluate decisions regarding marke	ting and innovation strategies		
	Analyze markets by applying market and technolo	gy portfolios		
	Conduct forecasts and develop compelling scenari			
	Translate customer needs into concepts, prototype		fully apply adv	anced methods for
	<ul> <li>customer-oriented product and service developme</li> <li>Use adequate methods to foster efficient diffusion</li> </ul>			
	Choose suitable pricing strategies and communical			
	Make strategic sales decisions for products and se			
	Apply methods of sales force management (i.e. cu	stomer value analysis)		
Personal Competence				
· ·	The students will be able to			
,				
	<ul> <li>have fruitful discussions and exchange arguments</li> <li>develop original results in a group</li> </ul>			
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
			h	bla £alda
	<ul> <li>Acquire knowledge independently in the specific c</li> <li>Consider proposed business actions in the field of</li> </ul>		ner new compi	ex problem fields.
	Consider proposed business decions in the neid of	marketing and reneet on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement				
	Subject theoretical and practical work	nation		
Examination duration and scale	Written elaboration, excercises, presentation, oral partici	pauoII		
Assignment for the	Global Technology and Innovation Management & Entrep	reneurship: Core Qualification: Compute	orv	
Following Curricula	1		-	
	Mechanical Engineering and Management: Specialisation		•	
	Biomedical Engineering: Specialisation Artificial Organs a	nd Regenerative Medicine: Elective Com	npulsory	
	Biomedical Engineering: Specialisation Implants and End			
	Biomedical Engineering: Specialisation Medical Technology		sory	
	Biomedical Engineering: Specialisation Management and	Business Administration: Compulsory		

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

Course L0862: PBL Marketing	ourse 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: Appli	ed Design Methodology in Me	chatronics			
Courses					
Title		Т	ур	Hrs/wk	СР
Applied Design Methodology in Med	chatronics (L1523)	L	ecture	2	2
Applied Design Methodology in Med	chatronics (L1524)	Р	roject-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical design	ign or computer-science	S		
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have	ve reached the following	learning results		
Professional Competence					
Knowledge	Science-based working on interdisciplinary	product design consider	ring targeted application of spe	ecific product	design techniques
Skills	Creative handling of processes used for sci		formulation of complex produc	ct design prob	lems / Application of
	various product design techniques following	g theoretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical	l-scientific tasks from a	n industrial context in small	design-teams	with application of
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the desig	gn and development pro	cess according to the target ar	nd topic of the	design
Workload in Hours	Independent Study Time 110, Study Time i	in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-wor	rk			
scale					
Assignment for the	International Management and Engineering	g: Specialisation II. Produ	ict Development and Production	on: Elective Co	ompulsory
Following Curricula	International Management and Engineering	g: Specialisation II. Mech	atronics: Elective Compulsory		
	Mechanical Engineering and Management:	Specialisation Product D	evelopment and Production: E	Elective Comp	ulsory
	Mechatronics: Specialisation System Design	n: Elective Compulsory			
	Biomedical Engineering: Specialisation Arti	ificial Organs and Regen	erative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Imp	plants and Endoprosthes	es: Elective Compulsory		
	Biomedical Engineering: Specialisation Med	dical Technology and Co	ntrol Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Mar	nagement and Business	Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specia	alisation Product Develo	oment and Production: Elective	e Compulsory	

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>
Literature	<ul> <li>Definition folgt</li> <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: Applied Desig	Course L1524: Applied Design Methodology in Mechatronics	
Тур	Project-/problem-based Learning	
Hrs/wk	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

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Courses				
litle little		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1 2
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	none, module "organic chemistry", module	"fundamentals for process engineering"		
<b>Educational Objectives</b>	After taking part successfully, students have	re reached the following learning results		
<b>Professional Competence</b>				
	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry a 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.  After successful completion of this module, students should be able to			
	<ul> <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 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 microaero 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> <li>to document and discuss their procedures as well as results in a scientific manner</li> </ul>			
Personal Competence Social Competence Autonomy	After completion of this module participant take position to their own opinions and income	ts should be able to debate technical questions rease their capacity for teamwork in engineering ts will be able to solve a technical problem in a plenum.	and scientific envi	ronments.
Workload in Hours	Independent Study Time 96, Study Time in	Lecture 84		
Credit points				
Course achievement		<b>Description</b> al and		
Examination	Written exam			
Examination duration and scale				
Assignment for the	General Engineering Science (German prog	gram, 7 semester): Specialisation Process Engine	ering: Compulsory	
Following Curricula	General Engineering Science (German prog	gram, 7 semester): Specialisation Bioprocess Eng	gineering: Compulso	ory
	Bioprocess Engineering: Core Qualification:	Compulsory		
	Green Technologies: Energy, Water, Climat	e: Specialisation Bioresource Technology: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Arti	ficial Organs and Regenerative Medicine: Compu	ilsory	
	Biomedical Engineering: Specialisation Imp	lants and Endoprostheses: Elective Compulsory		
	Diomedical Engineering opecialisation imp			
		dical Technology and Control Theory: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Med	dical Technology and Control Theory: Elective Conagement and Business Administration: Elective		
	Biomedical Engineering: Specialisation Med	nagement and Business Administration: Elective		

Course L0841: Bioprocess Engineering - Fundamentals		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Andreas Liese	
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>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-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	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012  H. Chmiel: Bioprozeßtechnik, Elsevier, 2006  R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010  H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997  P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013	

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

Course L0843: Bioprocess En	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 M1277: MED	I: Introduction to Anatomy
Courses	
Title	Typ Hrs/wk CP
Introduction to Anatomy (L0384)	Lecture 2 3
Module Responsible	Prof. Udo Schumacher
Admission Requirements	None
Recommended Previous	None
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system.
	The students can describe the basic macroscopy and microscopy of those systems.
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; the
	can explain the relevance of structures and their functions in the context of widespread diseases.
Personal Competence	
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui
	the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	
Examination	Written exam
Examination duration and	90 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	Compulsory
	Data Science: Specialisation Medicine: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

urse L0384: Introduction t	to Anatomy	
Тур	Lecture	
Hrs/wk	2	
СР		
	Independent Study Time 62, Study Time in Lecture 28	
	Prof. Tobias Lange	
Language		
	SoSe General Anatomy	
Content	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	
	7 <sup>th</sup> week: Genito-urinary System	
	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/Michael Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016	

Courses		
Γitle	Тур	Hrs/wk CP
ntroduction to Physiology (L0385)	Lecture	2 3
Module Responsible	Dr. Roger Zimmermann	
Admission Requirements	None	
Recommended Previous	None	
Knowledge		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning result	IS .
<b>Professional Competence</b>		
Knowledge	The students can	
	describe the basics of the energy metabolism;	
	describe physiological relations in selected fields of muscle, heart/circulations	on, neuro- and sensory physiology.
g/ ///		
Skills	The students can describe the effects of basic bodily functions (sensory, transmis	ssion and processing of information, developi
Porconal Competence	of forces and vital functions) and relate them to similar technical systems.	
Personal Competence Social Competence	The students can conduct discussions in research and medicine on a technical lev	rol.
30Clar Competence	The students can find solutions to problems in the field of physiology, both analytic	
	The stadents can ma solutions to prosicing in the new of physiology, sound analys	real and metrological
Autonomy	The students can derive answers to questions arising in the course and other	physiological areas, using technical literatur
	themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	3	
Course achievement	None	
Examination	Written exam	
Examination duration and	60 minutes	
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biom	edical Engineering: Compulsory
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation	Mechanical Engineering, Focus Biomecha
	Compulsory	
	Data Science: Specialisation Medicine: Compulsory	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation	
	Compulsory	Prechanical Engineering, Focus Diomecha
	General Engineering Science (English program, 7 semester): Specialisation Biome	edical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biome	
	Mechanical Engineering: Specialisation Biomechanics: Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: E	lective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration	: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicir	ne: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Co	mpulsory

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

Module M1278: MED	l: Introduction to Radiology and Radiation Therapy
Courses	
Title	Typ Hrs/wk CP
Introduction to Radiology and Radio	
Module Responsible	Prof. Ulrich Carl
Admission Requirements	None
Recommended Previous	None
Knowledge	After taking part suggestible students have reached the following learning results
Professional Competence	After taking part successfully, students have reached the following learning results
Knowledge	Therapy
	The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).
	The students can describe the patients' passage from their initial admittance through to follow-up care.
	Diagnostics
	The students can illustrate the technical base concepts of projection radiography, including 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 treatment method depending on the patient's clinical history and needs.
	The student can explain the influence of technical errors on the imaging techniques.
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	Therapy
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.
	The students can use the therapeutic principle (effects vs adverse effects)
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).
	Diagnostics
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge o 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	90 minutes
scale Assignment for the Following Curricula	
	Data Science: Specialisation Medicine: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory  Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1335: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is reco	mmended.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the follo	wing learning results		
<b>Professional Competence</b>				
Knowledge	The students can name the different kinds of artificial limbs.			
CI-:II-	The shirt share and size the sading share and disading share	-£ -liff   .i £	I	
SKIIIS	The students can explain the advantages and disadvantages	or different kinds of end	ioprotneses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to endoprothe	se with student mates a	and the teachers.	
Autonomic	The students are able to acquire information on their own. Th	ov san also judgo the in	formation with respect to	ita aradibility
Autonomy	The Students are able to acquire information on their own. Th	ey can also judge the ii	normation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Specialisation II.	Process Engineering an	d Biotechnology: Elective (	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid Materials: E	Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and R	egenerative Medicine: I	Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopros			
	Biomedical Engineering: Specialisation Medical Technology ar	•		
	Biomedical Engineering: Specialisation Management and Busi	ness Administration: Ele	ective Compulsory	
	Orientation Studies: Core Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Bio- and M	edical Technology: Elec	tive Compulsory	

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

Module M0845: Feedb	pack Control in Medical Techno	ology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techno	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.		w. Fundamentals in	
	Internal control loops of the human body example in for anesthesia control.	will be discussed in the same way like the o	design of external clo	osed loop system fo
	The handling of PID controllers and mode illustrated. The operation of simple equivale	rn controller like predictive controller or fuz ent circuits will be discussed.	zzy controller or neur	ral networks will be
Skills	Application of modeling, identification, control technology in the field of medical technology.			
Personal Competence Social Competence	Students can develop solutions to specific p	roblems in small groups and present their res	ults	
Autonomy		re and to set it into the context of the lectur eir learning process. They can combine kno	•	-
Workload in Hours	Independent Study Time 62, Study Time in I	Lecture 28		
	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Medica	al Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Contro	ol and Power Systems Engineering: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Impl	ants and Endoprostheses: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Artifi	icial Organs and Regenerative Medicine: Elect	ive Compulsory	
		agement and Business Administration: Electiv		
	Biomedical Engineering: Specialisation Medi	ical Technology and Control Theory: Compulso	ory	

Course L0664: Feedback Con	itrol in Medical Technology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows:
	<ul> <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> <li>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.</li> </ul>
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 MU832: AdVa	nced Topics in Control
Courses	
Title	Typ Hrs/wk CP
Advanced Topics in Control (L0661	L) Lecture 2 3
Advanced Topics in Control (L0662	Recitation Section (small) 2 3
Module Responsible	Prof. Herbert Werner
Admission Requirements	None
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	<ul> <li>Students can explain the advantages and shortcomings of the classical gain scheduling approach</li> <li>They can explain the representation of nonlinear systems in the form of quasi-LPV systems</li> <li>They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions</li> <li>They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems</li> <li>They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniq associated with each of these model structures</li> <li>Students can explain how graph theoretic concepts are used to represent the communication topology of multiag systems</li> <li>They can explain the convergence properties of first order consensus protocols</li> <li>They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models</li> <li>Students can explain concepts behind linear and qLPV Model Predictive Control (MPC)</li> </ul>
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	
Examination	
Examination duration and	
examination duration and scale	
Scale	
Assignment for the	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
	Mechatronics: Specialisation System Design: 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
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

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

Course L0662: Advanced Top	ourse L0662: Advanced Topics in Control	
Тур	Recitation Section (small)	
Hrs/wk	2	
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	

	ectromagnetics: Principles a				
Courses					
Title		Т	ур	Hrs/wk	СР
Bioelectromagnetics: Principles and	* *		ecture	3	5
Bioelectromagnetics: Principles and	1	Re	ecitation Section (small)	2	1
•	Prof. Christian Schuster				
Admission Requirements					
Recommended Previous Knowledge	Basic principles of physics				
<b>Educational Objectives</b>	After taking part successfully, students h	nave reached the following	learning results		
Professional Competence					
Knowledge	Students can explain the basic principles of electromagnetic fields in biological ti them corresponding to wavelength and techniques for characterization of elect diagnostic utilization of electromagnetic	ssue. They can define and I frequency of the fields. <sup>-</sup> romagnetic fields in practi	exemplify the most imp They can give an overvion cal applications . They ca	ortant physical ph ew over measure	nenomena and order ment and numerica
Skills	Students know how to apply various met do this they can relate to and make us important effects that these models pr frequency, respectively, and they can a predictions. They are able to evaluate th appropriate choice.	se of the elementary soluti redict for biological tissue, nalyze them in a quantitati	ons of Maxwell's Equation they can order the effective way. They are able to	ns. They are able cts corresponding develop validation	to assess the most to wavelength an strategies for their
Personal Competence Social Competence	Students are able to work together on s English (e.g. during small group exercise	•	all groups. They are able	e to present their	results effectively i
Autonomy	Students are capable to gather inform context of the lecture. They are able to other lectures (e.g. theory of electroms problems and effects in the field of bioel	make a connection betwe	en their knowledge obtai	ned in this lecture	with the content of
Workload in Hours	Independent Study Time 110, Study Tim	e in Lecture 70			
Credit points					
Course achievement	Compulsory Bonus Form	Description			
	Yes None Presentation				
Examination					
Examination duration and .					
scale					
Assignment for the	Electrical Engineering: Specialisation Mic	crowave Engineering, Optic	s, and Electromagnetic Co	ompatibility: Electi	ve Compulsory
Following Curricula				-	-
	International Management and Engineer	ing: Specialisation II. Electr	ical Engineering: Elective	Compulsory	
	Biomedical Engineering: Specialisation M	Management and Business A	Administration: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Ir	mplants and Endoprosthese	es: Elective Compulsory		
	Biomedical Engineering: Specialisation A	artificial Organs and Regene	erative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation M	Medical Technology and Cor	ntrol Theory: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Spe	cialisation Bio- and Medica	l Technology: Elective Cor	mpulsory	

Course L0371: Bioelectromag	gnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

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

## **Specialization Management and Business Administration**

Module M0623: Intelli	igent Systems in Medicine			
C				
Courses		Tue	Hun hade	CD
Title Intelligent Systems in Medicine (LO.	331)	<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Intelligent Systems in Medicine (LO		Project Seminar	2	2
Intelligent Systems in Medicine (LO		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous	• principles of math (algebra, analysis/salsylys)			
Knowledge	<ul><li>principles of math (algebra, analysis/calculus)</li><li>principles of stochastics</li></ul>			
	<ul> <li>principles of stochastics</li> <li>principles of programming, Java/C++ and R/Mat</li> </ul>	lah		
	advanced programming skills	ido		
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge	The students are able to analyze and solve clinical tr			
	optimization, and planning. They are able to explain m			
	in clinical contexts. The students can compare differe			
	in the context of clinical data and explain challenges	due to the clinical nature of the data	and its acquisitio	n 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 evaluat	e the implemented methods.		
Personal Competence				
•	The students discuss the results of other groups, provi	de helpful feedback and can incoorpor	ate feedback into	their work
Social competence	The students diseass the results of other groups, provi	ac neipiai recaback and can incoorpor	ate recuback into	then work.
Autonomy	The students can reflect their knowledge and docume	ent the results of their work. They car	present the resu	ılts in an appropriate
	manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 7	0		
Credit points	6			
Course achievement		cription		
	Yes 10 % Presentation			
	Yes 10 % Written elaboration			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intelligence Engin	eering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Medical Technology	gy: Elective Compulsory		
	Interdisciplinary Mathematics: Specialisation Computa		Compulsory	
	Mechatronics: Specialisation Intelligent Systems and R	·		
	Biomedical Engineering: Specialisation Artificial Organ	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and E		I	
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management a			
	Theoretical Mechanical Engineering: Specialisation Bio	- and Medical Technology: Elective Col	ripuisoi y	

Course L0331: Intelligent Sy	stems in Medicine
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<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 Sy	urse L0334: Intelligent Systems in Medicine		
Тур	Project Seminar		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Alexander Schlaefer		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L0333: Intelligent 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	

Module M1230: Selec	ted Topics of Biomedical Engineering	J - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	anics (L0377)	Lecture	2	3
Experimental Methods for the Char	racterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	es (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory		
-	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			
	biomedical engineering: Specialisation Management a	ilia basilless Adiliillistiatioli. Elective Ct	Jilipuisory	

Course L1663: Nature's Hiera	archical Materials
	Seminar
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
Examination Form	
Examination duration and	Nausui
scale	
	Prof. Gerold Schneider
Language	
Cycle	
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
	Journal publications

Тур	Lecture
Hrs/wk	
CP	
Workload in Hours	
Examination Form	
Examination duration and	
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well a Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.  Topics:  - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Libountour	- Zinko Brunswig "Hachfraguanztechnik 1" Springer (1990)
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

Course L1588: Development	and Regulatory Approval of Medical Devices
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<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 L0377: Experimental	Mathods in Riemachanics
·	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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 Biom	nedical Engineering
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Referat
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

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

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes  • Modelling and limits of model  • Time constant, stiffness, stability, step size  • Terms of object orientated programming  • Differential equations of simple systems  • Introduction into Modelica  • Introduction into simulation tool  • Example: Hydraulic systems and heat transfer  • Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>

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

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

Module M0775: Ergon	nomics			
Courses				
Title		Тур	Hrs/wk	СР
Ergonomics (L0653)		Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	eached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lec	ture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering: Sp	ecialisation II. Product Development and	Production: Elective Co	ompulsory
Following Curricula	Biomedical Engineering: Specialisation Implant	·	•	
	Biomedical Engineering: Specialisation Artificia			
	Biomedical Engineering: Specialisation Manage			
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective	e Compulsory	

Course L0653: Ergonomics	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Armin Bossemeyer
Language	DE
Cycle	WiSe
Content	
Literature	

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	1 Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have r	reached the following learning results		
<b>Professional Competence</b>				
	(goals, utilities, environments). They can desc can be discussed in terms of decision proble world scenarios, students can summarize how formalism in static and dynamic settings. In settings, with and with complete access to t solving (partially observable) Markov decision Students can identify techniques for simultar desired states. Students can explain coordina of equilibria, social choice functions, voting pr Students can select an appropriate agent an students can derive decision trees and apply networks/dynamic Bayesian networks and a different sampling techniques for simplified a best action or policies for concrete settings. I	define intelligence in terms of rational behavior cribe the main features of environments. The notems and algorithms for solving these problems. We Bayesian networks can be employed as a known addition, students can define decision making the state of the environment. In this context, on problems, and they can recall techniques for neous localization and mapping, and can explait to problems and decision making in a multi-action of the context of the environment. In this context, on problems, and they can recall techniques for neous localization and mapping, and can explait the problems and decision making in a multi-action problems and decision making in a multi-action problems and decision making techniques. For those application scenarios of the problems and complex decision multi-agent situations students will apply different voting the problems are students will apply different voting the problems are students will apply different voting the problems.	otion of adversaria. For dealing with owledge represent procedures in sistudents can destructed at the control of the control	al agent cooperate uncertainty in restation and reason mple and sequencribe techniques value of informatiniques for achieverm of different typed agent applicated also create Bayes so name and applicts can compute g different equilit
Personal Competence				
Social Competence	Students are able to discuss their solutions to	problems with others. They communicate in En	glish	
4				
Autonomy	students are able of checking their understan	iding of complex concepts by solving varaints of	concrete problen	115
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
	6			
Credit points				
Credit points Course achievement	None			
Course achievement	None Written exam			
Course achievement	Written exam			
Course achievement Examination	Written exam			
Course achievement Examination Examination duration and	Written exam 90 minutes	ce Engineering: Elective Compulsory		
Course achievement Examination Examination duration and scale	Written exam 90 minutes  Computer Science: Specialisation II: Intelligen	ice Engineering: Elective Compulsory Specialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam 90 minutes  Computer Science: Specialisation II: Intelligen	Specialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent System	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective (		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implant	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective Conts and Endoprostheses: Elective Compulsory	Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implan Biomedical Engineering: Specialisation Medical	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective (	Compulsory	

Course L0341: Intelligent Au	tonomous Agents and Cognitive Robotics
	Lecture
	2
	4
	Independent Study Time 92, Study Time in Lecture 28
	Rainer Marrone
Content	
	Definition of agents, rational behavior, goals, utilities, environment types
	Adversarial agent cooperation:
	Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of
	chance
	Uncertainty:
	Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product
	rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity,
	independence assumptions, naive Bayes, conditional independence assumptions
	Bayesian networks:  Control and contacting of Bayesian actuable properties assigned (information by accuration) busined and accurate and accurate actually accurate accur
	Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case
	complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly
	perceived).
	Probabilistic reasoning over time:  Environmental state may shape even without the agent performing actions dynamic Payesian networks. Markey
	Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation,
	special cases: hidden Markov models, Kalman filters, Exact inferences and approximations
	Decision making under uncertainty:
	Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio
	Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs
	Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks
	Simultaneous Localization and Mapping
	Planning
	Game theory (Golden Balls: Split or Share)
	Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium
	Social Choice
	Voting protocols, preferences, paradoxes, Arrow's Theorem,
	Mechanism Design
	Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem,
	Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality
	mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite
	Theorem
Literature	1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-
	11, 13-17
	2. Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge
	University Press, 2009
	l.

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

Module M0751: Vibra	tion Theory				
Courses					
Title		Тур	Hrs/wk	СР	
Vibration Theory (L0701)		Integrated Lecture	4	6	
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	<ul><li>Calculus</li><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>				
<b>Educational Objectives</b>	After taking part successfully, students have reached t	he following learning results			
Professional Competence					
Knowledge	Students are able to denote terms and concepts of Vib	ration Theory and develop them furt	ther.		
Skills	Students are able to denote methods of Vibration Theo	ry 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 5	5			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Energy Systems: Core Qualification: Elective Compulso	ry			
Following Curricula	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Compu	ulsory		
	Mechanical Engineering and Management: Specialisati	on Mechatronics: Elective Compulsor	ry		
	Mechatronics: Core Qualification: Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs	9	, ,		
	Biomedical Engineering: Specialisation Implants and En				
	Biomedical Engineering: Specialisation Medical Techno	,	. ,		
	Biomedical Engineering: Specialisation Management at		Compulsory		
	Product Development, Materials and Production: Core	. ,			
	Naval Architecture and Ocean Engineering: Core Qualification	, ,			
	Theoretical Mechanical Engineering: Core Qualification	. Elective Compulsory			

Course L0701: Vibration The	ory	
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	f. Norbert Hoffmann	
Language	/EN	
Cycle	Se Se	
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.	

	Elements Methods			
Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (I	arge) 2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Mater	als) and Mechanics II (Hydrostatics, Kinema	atics, Dynamics)	
Knowledge	Mathematics I, II, III (in particular differer	tial equations)		
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth know overview of the theoretical and methodic	rledge regarding the derivation of the fin al basis of the method.	ite element method and	are able to give
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the correspondin system matrices, and solving the resulting system of equations.			
Personal Competence Social Competence	Students can work in small groups on spo	ecific problems to arrive at joint solutions.		
Autonomy	The students are able to independentl Problems can be identified and the result	r solve challenging computational problems are critically scrutinized.	ms and develop own fin	ite element routin
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 56		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Con	npulsory		
Following Curricula	Energy Systems: Core Qualification: Elec	ive Compulsory		
	Aircraft Systems Engineering: Specialisat	ion Aircraft Systems: Elective Compulsory		
	Aircraft Systems Engineering: Specialisat	ion Air Transportation Systems: Elective Co	mpulsory	
	Aircraft Systems Engineering: Core Quali	fication: Elective Compulsory		
	International Management and Engineeri	ng: Specialisation II. Mechatronics: Elective	Compulsory	
		ng: Specialisation II. Product Development		Compulsory
	Mechatronics: Core Qualification: Compu			. ,
	· ·	pplants and Endoprostheses: Compulsory		
	3 3 1	anagement and Business Administration: E	lective Compulsory	
		edical Technology and Control Theory: Elec		
		tificial Organs and Regenerative Medicine:		
	Product Development, Materials and Product Development	3	2.22dive compulsory	
	•	agineering Science: Elective Compulsory		

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

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

ourses				
itle		Тур	Hrs/wk	СР
echnology Management (L0849) echnology Management Seminar	(1.0850)	Lecture Project-/problem-based Learning	3	3
	Prof. Cornelius Herstatt	Troject /problem basea teaming	-	3
Admission Requirements	None			
Recommended Previous	Bachelor knowledge in business management			
Knowledge	Sucheron kind medge in Susmess management			
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
<b>Professional Competence</b>				
Knowledge	Students will gain deep insights into:			
	<ul> <li>International R&amp;D-Management</li> </ul>			
	Technology Timing Strategies			
	<ul> <li>Technology Strategies and Lifecycle N</li> </ul>	Management (I/II)		
	<ul> <li>Technology Intelligence and Planning</li> </ul>	•		
	Technology Portfolio Management			
	<ul> <li>Technology Portfolio Methodology</li> </ul>			
	<ul> <li>Technology Acquisition and Exploitati</li> </ul>	ion		
	IP Management			
	Organizing Technology Development     Technology Organization & Management	ant		
	<ul> <li>Technology Organization &amp; Managem</li> <li>Technology Funding &amp; Controlling</li> </ul>	ent		
Skills	The course aims to:			
Skills	The course aims to.			
	Develop an understanding of the importance			
	Equip students with an understanding of important elements of Technology Management (strategic, operational			
	organizational and process-related aspects)  • Foster a strategic orientation to problem-sc	dving within the innovation process as well a	s Technology I	Management and
	importance for corporate strategy	well a	3 iccilliology i	nanagement and
	Clarify activities of Technology Management	t (e.g. technology sourcing, maintenance and	exploitation)	
	Strengthen essential communication skills	and a basic understanding of managerial, o	organizational	and financial iss
	concerning Technology-, Innovation- and R&	D-management. Further topics to be discusse	d include:	
	Basic concents, models and tools, relevant to	to the management of technology, R&D and in	novation	
	<ul> <li>Innovation as a process (steps, activities and</li> </ul>		novation	
Personal Competence				
Social Competence	Interact within a team			
	Raise awareness for globabl issues			
Autonomy				
Autonomy	<ul> <li>Gain access to knowledge sources</li> </ul>			
	Discuss recent research debates in the cont	ext of Technology and Innovation Managemen	t	
	<ul> <li>Develop presentation skills</li> </ul>			
	<ul> <li>Discussion of international cases in R&amp;D-Ma</li> </ul>	nagement		
Workload in Hours	Independent Study Time 110, Study Time in Lectur	re 70		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the	Global Innovation Management: Core Qualification	: Compulsory		
Following Curricula	International Management and Engineering: Specia	, ,	mpulsorv	
	Mechanical Engineering and Management: Special	·	p	
	Biomedical Engineering: Specialisation Artificial Or		npulsory	
	Biomedical Engineering: Specialisation Implants ar	nd Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	chnology and Control Theory: Elective Compul	sory	
	Biomedical Engineering: Specialisation Manageme	nt and Business Administration: Compulsory		

Course L0849: Technology M	lanagement
Тур	Lecture
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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology M	anagement Seminar
Тур	Project-/problem-based Learning
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
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.

	<u></u>		<u></u>			
Courses						
Title				Тур	Hrs/wk	СР
Microsystems Technology (L0724)				Lecture	2	4
Microsystems Technology (L0725)				Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous	Basics in physics, chemistry, mech	ianics and s	emiconductor tech	inology		
Knowledge Educational Objectives	A Strandard in the stra	la-sta la-ssa				
Professional Competence	After taking part successfully, stud	ients nave n	eached the following	ng learning results		
•	Students are able					
Knowieuge	Students are able					
	<ul> <li>to present and to explain or microsensors and microactuators,</li> </ul>		•	for microstructures and especia eof in more complex systems	ally methods fo	or the fabrication o
	to explain in details operation	principles o	f microsensors and	d microactuators and		
	to discuss the potential and lin	mitation of n	nicrosystems in ap	plication.		
Skills	Students are capable					
	to analyze the feasibility of mi	crosystems				
	to develop process flows for the state of the state			es and		
	to develop process flows for the	ie lablicatio	ii oi iiiciosti actai	es and		
	• to apply them.					
Personal Competence Social Competence	Students are able to prepare and of audience.	perform the	ir lab experiments	in team work as well as to preso	ent and discus:	s the results in fror
Autonomy	None					
Workload in Hours	Independent Study Time 124, Stud	dy Time in L	ecture 56			
Credit points	6 Compulsory Bonus Form		Description			
Course achievement	Yes None Subject t practical w		andStudierender	n führen in Kleingruppen ein La nd diskutiert die Theorie sowie o amten Kurs.		
Examination	Oral exam					
Examination duration and	30 min		·		-	
scale						
Assignment for the	Electrical Engineering: Specialisati	on Nanoeled	tronics and Micros	systems Technology: Elective Co	mpulsory	
Following Curricula	Electrical Engineering: Specialisati					
	International Management and En					
	Biomedical Engineering: Specialisa					
	Biomedical Engineering: Specialisa					
	Biomedical Engineering: Specialisa Biomedical Engineering: Specialisa	-		·	-	
	2.3caicai Engineering. Specialise		Jiganis ana negi	concordante incurcinco Elective Coll	. p a 1501 y	

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-general lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering: 0 techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etch anisotropic etching with KOH/TMAH: theory, corner undercrutting, measures for compensation and etch-stop techniqu plasma processes, dry etching: back sputtering, plasma etching, Rile, Bosch process, cryo process, Xe72 etching)</li> <li>Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measurement)</li> <li>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 thermor modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pinunction, NTC and PTC; thermal anemome mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sen piezoresistive, capacitive and fabrication process, accelerometer: piezoresistive, piezoelectric and capacitive; angular r sensor: operating principle and fabrication process, accelerometer: piezoresistive, piezoelectric and capacitive; angular r sensors: operating principle and fabrication process, scalenometer)</li> <li>Chemical and Bio Sensors (thermal gas sensors: splining current Hall sensor and magneto-transistor; magnetoresis sensors: magnetor resistance, AMR and GMR, fluxgate magnetometer)</li> <li>Chemical and Bi</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

Course L0725: Microsystems	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		

Module M0846: Contr	ol Systems Theory and Desi	gn		
Courses				
<b>Title</b> Control Systems Theory and Design	n (L0656)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 4
Control Systems Theory and Design	n (L0657)	Recitation Section (small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements				
Recommended Previous	Introduction to Control Systems			
Knowledge	After taking part successfully, students h	ave reached the following learning results		
Professional Competence		ave reaction the following learning results		
Knowledge Skills	Students can explain how linear or response to initial states or extern. They can explain the system propestimation, respectively They can explain the significance or They can explain observer-based sor They can explain observer-based sor They can explain the z-transform and They can explain the z-transform and They can explain the experimental be solved by solving a normal equivation. They can explain how a state space  Students can transform transfer furuments to the transform transfer furuments. They can assess controllability and They can design LQG controllers for They can carry out a controller deform a given sampling rate. They can identify transfer function.	state feedback and how it can be used to achieve of multi-input multi-output systems and its relationship with the Laplace Transform also and transfer function models of discrete-time of identification of ARX models of dynamic systems ation at model can be constructed from a discrete-time of the model can be constructed from a discrete-time on the models into state space models and vice we doservability and construct minimal realisations.	relationship to state tracking and disturent systems so, and how the identification impulse response tersa	e feedback and state  bance rejection  cification problem can  which is appropriate
	when solving given problems.	ecific problems to arrive at joint solutions. rovided sources (lecture notes, software docum		nt guides) and use it
Workload in Hours	, , , , , , , , , , , , , , , , , , , ,	e in Lecture 56		
Credit points				
Course achievement				
Examination  Examination duration and	Written exam			
examination duration and scale				
	Electrical Engineering: Core Qualification:	: Compulsory		
Following Curricula				
	International Management and Engineeri International Management and Engineeri Mechanical Engineering and Managemen Mechatronics: Core Qualification: Compul Biomedical Engineering: Specialisation Ar Biomedical Engineering: Specialisation In Biomedical Engineering: Specialisation M Biomedical Engineering: Specialisation M	Specialisation II. Engineering Science: Elective Cong: Specialisation II. Electrical Engineering: Electing: Specialisation II. Mechatronics: Elective Compt: Specialisation Mechatronics: Elective Compulsor:	ve Compulsory ulsory vry ve Compulsory ry	

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

Course L0657: Control Syste	ourse 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		

ourses					
itle		Тур	Hrs/wk	CP	
he Digital Enterprise (L0932)		Lecture	2	2	
roduction Planning and Control (L	·	Lecture	2	2	
roduction Planning and Control (L xercise: The Digital Enterprise (L0		Recitation Section (small)	1 1	1	
		Recitation Section (small)	1	1	
Module Responsible	Prof. Hermann Lödding				
Admission Requirements					
	Fundamentals of Production and Quali	ity Management			
Knowledge					
	After taking part successfully, student	s have reached the following learning results			
Professional Competence					
Knowledge	Students can explain the contents of t	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.				
Personal Competence					
Social Competence	Students can develop joint solutions in mixed teams and present them to others.				
Autonomy	-				
Workload in Hours	Independent Study Time 96, Study Tir	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6				
Course achievement	None				
Examination	Written exam				
Examination duration and	180 Minuten				
scale					
Assignment for the	International Management and Engine	eering: Specialisation II. Product Development and Prod	uction: Elective Co	ompulsory	
Following Curricula	Logistics, Infrastructure and Mobility:	Specialisation Production and Logistics: Elective Compu	ulsory		
	Biomedical Engineering: Specialisation	n Artificial Organs and Regenerative Medicine: Elective	Compulsory		
	Biomedical Engineering: Specialisation	n Implants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation	n Medical Technology and Control Theory: Elective Com	npulsory		
	Biomedical Engineering: Specialisation	n Management and Business Administration: Compulso	ry		
	Product Development, Materials and F	Production: Specialisation Product Development: Electiv	e Compulsory		
	Product Development, Materials and F	Production: Specialisation Production: Compulsory			
	Product Development, Materials and F	Production: Specialisation Materials: Elective Compulsor	У		
	Theoretical Mechanical Engineering: S	Specialisation Product Development and Production: Ele	ctive Compulsory		

Course L0932: The Digital Er	ourse L0932: The Digital Enterprise				
Тур	Lecture				
Hrs/wk	2				
СР	2				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Lecturer	Dr. Axel Friedewald				
Language	DE				
Cycle	WiSe				
	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: Exercise: The	Course L0933: Exercise: The Digital Enterprise		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Dr. Axel Friedewald		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	Siehe korrespondierende Vorlesung		
	See interlocking course		

Module M0921: Electi	ronic Circuits fo	r Medical Applica	ations			
Courses						
Title				Тур	Hrs/wk	СР
Electronic Circuits for Medical Applications (L0696)				Lecture	2	3
Electronic Circuits for Medical Appl				Recitation Section (small)	1	2
Electronic Circuits for Medical Appl	lications (L1408)			Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl					
Admission Requirements	None					
Recommended Previous		rical engineering				
Knowledge						
Educational Objectives		essfully, students have re	eached the following	ng learning results		
Professional Competence						
Knowledge		xplain the basic function	ality of the informa	ation transfer by the central	nervous system	
				ential and its propagation alo		
				ons and electronic devices	3	
				nplifiers for medical applicat	tions	
	Students can ex	xplain the functions of pr	ostheses, e. g. an	artificial hand		
	Students are all	ole to discuss the potenti	al and limitations	of cochlea implants and arti	ficial eyes	
Skills						
				vior of an action potential		
				w-noise and low-power sign	al acquisition.	
		levelop the block diagran				
	Students can de	efine the building blocks	of electronic syste	ems for an articifial eye.		
Danis and Comments and						
Personal Competence						
Social Competence	Students are to	ained to solve problems	s in the field of r	medical electronics in team	s together with ex	operts with different
	professional ba	ckground.				
	Students are all	ole to recognize their spe	cific limitations, so	o that they can ask for assis	tance to the right t	ime.
	• Students can d	ocument their work in a	clear manner and	d communicate their results	in a way that oth	ners can be involved
	whenever it is r	necessary				
Autonomy		able to realistically jude	a the status of	their knowledge and to de	ofine actions for i	marayamanta whan
	necessary.	ible to realistically Judg	e the status of	their knowledge and to de	enne actions for i	improvements when
	•	reak down their work in a	nnronriate work n	packages and schedule their	work in a realistic	way
				ectrical experiments without		way.
		·		ses and situations of experin		
	Stadents are as	ne to det in a responsible	ae a eas	es and steadtions of experim	Territor Works	
Workload in Hours	Independent Study Tir	me 124, Study Time in Le	ecture 56			
Credit points						
Course achievement	1	Form	Description			
	Yes None	Subject theoretical	and			
		practical work				
	No None	Excercises				
Examination	Written exam					
Examination duration and	90 min					
scale						
Assignment for the	Electrical Engineering	: Specialisation Medical T	echnology: Electiv	ve Compulsory		
Following Curricula	Biomedical Engineerin	g: Specialisation Artificia	l Organs and Reg	enerative Medicine: Elective	Compulsory	
	Biomedical Engineerin	g: Specialisation Implant	s and Endoprosth	eses: Elective Compulsory		
	Biomedical Engineerin	g: Specialisation Medical	Technology and	Control Theory: Compulsory		
	Biomedical Engineerin	g: Specialisation Manage	ement and Busines	ss Administration: Elective C	compulsory	
	Microelectronics and N	licrosystems: Specialisat	tion Microelectroni	ics Complements: Elective C	ompulsory	
	Theoretical Mechanica	ıl Engineering: Specialisa	tion Bio- and Med	ical Technology: Elective Co	mpulsory	

Course L0696: Electronic Circ	cuits 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 Cir	urse L1056: Electronic Circuits for Medical Applications		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	2		
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14		
Lecturer	Prof. Matthias Kuhl		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Course L1408: Electronic Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<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/

Module M1150: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g., i	n the module Mechanics II (forces and	d moments, stre	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain en	ergy).		
Educational Objectives	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to o	alculate the mechanical behavior of n	naterials.	
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions, to present the	nem to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own strengths and problems in the area of continuum mechanics and acqu	·	-	wn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Con	npulsory		
Following Curricula	Mechanical Engineering and Management: Specialisatio	n Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective			
	Biomedical Engineering: Specialisation Artificial Organs	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technolo		-	
	Biomedical Engineering: Specialisation Management and		mpulsory	
	Product Development, Materials and Production: Core Q			
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

Course L1533: Continuum Me	echanics
Тур	Lecture
Hrs/wk	2
CP	3
	Prof. Christian Cyron
Language	
Cycle	WISE
Content	Fundamentals of tensor calculus
	Transformation invariance
	Tensor algebra
	Tensor analysis
	Kinematics
	Motion of continuum
	Deformation of infinitesimal line, area and volume elements
	Material and spatial description
	Polar decomposition
	Spectral decomposition
	Objectivity
	Strain measures
	Time derivatives
	Partial / material time derivatives
	Objective time rates
	<ul><li>Strain and deformation rates</li></ul>
	Transport theorems
	Balance equations (global and local form)
	Balance of mass
	The stress state
	<ul> <li>Surface traction vectors</li> </ul>
	<ul><li>Cauchy's fundamental theorem</li></ul>
	<ul><li>Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)</li></ul>
	Balance of linear momentum
	Balance of angular momentum
	Balance of energy
	Balance of entropy
	Clausius-Duhem inequality
	Constitutive laws
	Constitutive assumptions
	• Fluids
	Elastic solids
	Hyperelasticity     Material commetry
	Material symmetry     Flacto plactic colide
	Elasto-plastic solids     Applyeis
	Analysis     Initial-boundary value problems and their numerical solution
	- midar-boundary value problems and their numerical solution
I ika ua tuun	P. Crovey Kentingumemachanik, Ein Crundkurs für Ingenieure und Dhysiker
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer
	waitere ciebe in der Literaturliste des Scripts
	weitere siehe in der Literaturliste des Scripts

Course L1534: Continuum Mo	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	

Module M1151: Mate	rials Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
<b>Recommended Previous</b>	Basics of linear and nonlinear continuum mechanics as	aught, e.g., in the modules Mechanic	s II and Continuu	m Mechanics (force
Knowledge	and moments, stress, linear and nonlinear strain, free-b	ody principle, linear and nonlinear con	stitutive laws, st	rain energy)
<b>Educational Objectives</b>	After taking part successfully, students have reached th	e following learning results		
<b>Professional Competence</b>				
Knowledge	The students can explain the fundamentals of multidime	nsional consitutive material laws		
Skills	The students can implement their own material laws in	finite element codes. In particular, the	e students can a	oply their knowledge
	to various problems of material science and evaluate th	e corresponding material models.		
Personal Competence				
Social Competence	The students are able to develop solutions, to present the	em to specialists and to develop idea	s further.	
Autonomy	The students are able to assess their own strengths and problems in the area of materials modeling and acquire	, ,	y and on their ov	vn identify and solv
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Com	pulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation	n Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Eng	oprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	gy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Core Q	ualification: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Mate	rials Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simu	lation Technology: Elective Compulso	ry	

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

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

Module M1199: Advar	nced Functional Materials	
Courses		
Title	Typ Hrs/wk CP	
Advanced Functional Materials (L16	625) Seminar 2 6	
Module Responsible	Prof. Patrick Huber	
Admission Requirements	None	
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in parti	cular
	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 overvie	w on
	modern materials science, which enables them to select optimum materials combinations depending on the tech	inical
	applications.	
Personal Competence		
· ·	The students are able to present solutions to specialists and to develop ideas further.	
,		
Autonomy	The students are able to	
	assess their own strengths and weaknesses.	
	gather new necessary expertise by their own.	
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28	
Credit points		
Course achievement	None	
Examination	Presentation	
Examination duration and	30 min	
scale		
Assignment for the	Materials Science: Core Qualification: Compulsory	
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory  Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	

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

Module M1241: Selec	ted Topics of Biomedical Engineering	J - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	anics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	ss (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	indoprostheses: Elective Compulsory		
-	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	

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

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

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

Course L1588: Development	and Regulatory Approval of Medical Devices		
Тур	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	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 L0377: Experimental Methods in Biomechanics		
·		
Тур	ecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content		
Literature	Wird in der Veranstaltung bekannt gegeben	

Course L1580: Experimental	Methods for the Characterization of Materials		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 min		
scale			
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber		
Language	DE		
Cycle	WiSe		
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

ourse L0001: Fluid Mechan			
Тур	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and			
scale			
Lecturer	Prof. Michael Schlüter		
Language	DE		
Cycle	WiSe		
Content			
	Differential equations for momentum-, heat and mass transfer		
	Examples for simplifications of the Navier-Stokes Equations		
	Unsteady momentum transfer      The place level transfer		
	<ul> <li>Free shear layer, turbulence and free jets</li> <li>Flow around particles - Solids Process Engineering</li> </ul>		
	Coupling of momentum and heat transfer - Thermal Process Engineering		
	Rheology - Bioprocess Engineering		
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering		
	Flow threw porous structures - heterogeneous catalysis		
	Pumps and turbines - Energy- and Environmental Process Engineering		
	Wind- and Wave-Turbines - Renewable Energy		
	Introduction into Computational Fluid Dynamics		
Litoroturo			
Literature	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.		
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.		
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.		
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg		
	2006.		
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.		
	6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunger		
	Springer Verlag, Berlin, Heidelberg, New York, 2006.		
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW		
	Fachverlage GmbH, Wiesbaden, 2008.		
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007		
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner		
	GWV Fachverlage GmbH, Wiesbaden, 2009.  10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.		
	10. Schäde, H.; Kunz, E.: Strömungsiehre. Verlag de Gruyter, Berlin, New York, 2007.  11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springe		
	Verlag, Berlin, Heidelberg, 2008.		
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.		
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.		
	25. Van Dyne, in All Album of Fluid Modion. The Furubolic F1655, Stafford California, 1002.		

Course L1820: System Simul	ation		
Тур	Lecture		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Examination Form	Mündliche Prüfung		
Examination duration and	30 min		
scale			
Lecturer	Dr. Stefan Wischhusen		
Language	DE		
Cycle	WiSe		
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes  • Modelling and limits of model  • Time constant, stiffness, stability, step size  • Terms of object orientated programming  • Differential equations of simple systems  • Introduction into Modelica  • Introduction into simulation tool  • Example: Hydraulic systems and heat transfer  • Example: System with different subsystems		
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>		

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

Course L0379: Ceramics Tech	nnology		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	Dr. Rolf Janßen		
Language			
Cycle	WiSe		
Content	based processing, e.g. "powder and cement science as well as	1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes	
		6. Densification, sintering	
		7. Glass and Cement technology	
		8. Ceramic-metal joining techniques	
Literature	W.D. Kingery, "Introduction to C	Ceramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991		
	D.W. Richerson, "Modern Ceran	nic Engineering", Marcel Decker, New York, 1992	
	Skript zur Vorlesung		

Courses			
Title		Тур	Hrs/wk CP
Introduction to Biochemistry and M		Lecture	2 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students h	ave reached the following learning results	
Professional Competence	The about substants		
Knowieage	The students can		
	<ul> <li>describe basic biomolecules;</li> </ul>		
	<ul> <li>explain how genetic information is</li> </ul>	coded in the DNA;	
	<ul> <li>explain the connection between D</li> </ul>	NA and proteins;	
Skills	The students can		
	recognize the importance of molecular	cular parameters for the course of a disease;	
	describe selected molecular-diagn		
	explain the relevance of these pro		
	·		
Personal Competence			
Social Competence	The students can participate in discussio	ns in research and medicine on a technical leve	el.
Autonomy	The students can develop understanding of topics from the course, 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	60 minutes		
scale			
Assignment for the	General Engineering Science (German pr	ogram, 7 semester): Specialisation Biomedical	Engineering: Compulsory
Following Curricula	General Engineering Science (German	program, 7 semester): Specialisation Mech	hanical Engineering, Focus Biomechan
	Compulsory		
	Data Science: Specialisation Medicine: Co	ompulsory	
	Electrical Engineering: Specialisation Med	dical Technology: Elective Compulsory	
	Engineering Science: Specialisation Biom		
		ogram, 7 semester): Specialisation Biomedical I	
		program, 7 semester): Specialisation Mech	nanical Engineering, Focus Biomechan
	Compulsory		
	Mechanical Engineering: Specialisation B	, ,	the Court land
		anagement and Business Administration: Elect	
		rtificial Organs and Regenerative Medicine: Ele	
		edical Technology and Control Theory: Elective	
		nplants and Endoprostheses: Elective Compuls	OI y
	Technomathematics: Specialisation III. En	igineering Science: Elective Compulsory	

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

Module M1334: BIO II	: Biomaterials		
Courses			
Title	Typ Hrs/wk CP		
Biomaterials (L0593)	Lecture 2 3		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is recommended.		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields o 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	90 min		
scale			
Assignment for the	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory		
Following Curricula	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: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0593: Biomaterials			
Typ			
Hrs/wk			
	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language			
Cycle	WiSe		
Content	Topics to be covered include:		
	Introduction (Importance, nomenclature, relations)		
	2. Biological materials		
	2.1 Basics (components, testing methods)		
	2.2 Bone (composition, development, properties, influencing factors)		
	2.3 Cartilage (composition, development, structure, properties, influencing factors)		
	2.4 Fluids (blood, synovial fluid)		
	3 Biological structures		
	3.1 Menisci of the knee joint		
	3.2 Intervertebral discs		
	3.3 Teeth		
	3.4 Ligaments		
	3.5 Tendons		
	3.6 Skin		
	3.7 Nervs		
	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.		
1 5k k	Hactings C and Duchovno B. Natural and living hismatorials. Peer Paters CRC Pro 1004		
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.		
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.		
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.		
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.		
	Wintermantel, E. und Ha, SW: Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.		

Module M1342: Polyn	ners			
Courses				
Title	v- (1.0200)	Тур	Hrs/wk	СР
Structure and Properties of Polyme Processing and design with polyme		Lecture Lecture	2 2	3 3
Module Responsible				
Admission Requirements	None			
· · · · · · · · · · · · · · · · · · ·	Basics: chemistry / physics / material scien	nce		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plastic	cs and define the necessary testing and analys	is.	
	They can explain the complex relationship	os structure-property relationship and		
	the interactions of chemical structure of the protection).	he polymers, including to explain neighboring o	contexts (e.g. sustaina	bility, environmenta
Skills	Students are capable of			
	<ul> <li>using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate a 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				
	and the state of t	of a constant of the constant of		
	- arrive at funded work results in heteroge	enius 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 weaknes	ses.		
	access their own state of learning in spec	sific terms and to define further work stone on	this basis	
	- assess their own state of learning in spec	cific terms and to define further work steps on	tilis basis.	
	- assess possible consequences of their pr	rofessional activity.		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Materials Science: Specialisation Engineer	ring Materials: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Im			
		tificial Organs and Regenerative Medicine: Elec		
	3 1	anagement and Business Administration: Electi	, ,	
	3 1	edical Technology and Control Theory: Elective	, ,	
	,	uction: Specialisation Production: Elective Com uction: Specialisation Materials: Elective Comp		
	' '	uction: Specialisation Materials: Elective Comp uction: Specialisation Product Development: El	*	
	· ·	ialisation Materials Science: Elective Compulso		

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

Course L1892: Processing an	d 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

Carriera					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (I 166	)	Seminar Seminar	2	3 3
Module Responsible		,	Seminar	2	<u> </u>
Admission Requirements  Recommended Previous					
Knowledge	None				
Educational Objectives	After taking part suc	eccfully ctudents have re	eached the following learning results		
Professional Competence	Arter taking part suc	essiany, stadents have re	defice the following learning results		
	After successful completion of the module students will be able to describe the basic methods of regenerative medicine a explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of method the cultivation of animal and human cells.				
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the baudnerlying principles of the discussed topics.				n explain the bas
Skills	After successful completion of the module students are  able to use medical databases for acquirierung and presentation of relevant up-to-date data independently  able to present their work results in the form of presentations  able to carry out basic cell culture methods and the corresponding analysis independently  able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine.				
Personal Competence Social Competence	defend them.		with 2-4 students to solve given tasks ar and discuss it with other students and team		in the plenary and
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 person independently including a presentation of the results.				
Workload in Hours	Independent Study T	me 124, Study Time in Le	ecture 56		
Credit points		· · · · · · · · · · · · · · · · · · ·			
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pro	otocol for lecture series	
Examination	Presentation				
<b>Examination duration and</b>	Oral presentation +	liscussion (30 min)			
scale					
Assignment for the	Biomedical Engineer	ng: Specialisation Implant	s and Endoprostheses: Elective Compuls	sory	
Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory				
	_	• .	ement and Business Administration: Elect		
	Biomedical Engineer	ng: Specialisation Medical	Technology and Control Theory: Elective	e Compulsory	

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

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

Module M1333: BIO I:	: Implants and Fracture Healing				
Courses					
Title	Typ Hrs/wk CP				
Implants and Fracture Healing (L03	876) Lecture 2 3				
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".				
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.				
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.				
61.71					
SKIIIS	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.				
Personal Competence					
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.				
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
Examination	Written exam				
<b>Examination duration and</b>	90 min				
scale					
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha				
Following Curricula	Compulsory				
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Engineering Science: Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha				
	Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	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 Compulsory  Orientation Studies: Core Qualification: Elective Compulsory				
	Orientation Studies: Core Qualification: Elective Compulsory  Technomathematics: Specialisation III. Engineering Science: Elective Compulsory				
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory				

Course L0376: Implants and	Fracture Healing			
Тур	Lecture			
Hrs/wk				
CP				
	ndependent Study Time 62, Study Time in Lecture 28 Prof. Michael Morlock			
Language				
Cycle				
Content	Topics to be covered include:			
	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)			
	Fracture Healing			
	1 Basics and biology of fracture repair			
	5.2 Clinical principals and terminology of fracture treatment			
	5.3 Biomechanics of fracture treatment			
	5.3.1 Screws			
	5.3.2 Plates			
	5.3.3 Nails			
	5.3.4 External fixation devices			
	5.3.5 Spine implants			
	6.0 New Implants			
Literature	Cochran V.B.: Orthopädische Biomechanik			
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics			
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine			
	Nigg, B.: Biomechanics of the musculo-skeletal system			
	Schiebler T.H., Schmidt W.: Anatomie			
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat			

Module M0630: Robot	tics and Naviga	tion in Medicine				
Courses						
<b>Title</b> Robotics and Navigation in Medicin Robotics and Navigation in Medicin Robotics and Navigation in Medicin	e (L0338)		<b>Typ</b> Lecture Project Seminar Recitation Section (small)	<b>Hrs/wk</b> 2 2 1	CP 3 2	
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous Knowledge	principles of principles	<ul> <li>principles of math (algebra, analysis/calculus)</li> <li>principles of programming, e.g., in Java or C++</li> <li>solid R or Matlab skills</li> </ul>				
Educational Objectives	After taking part succ	cessfully, students have re-	ached the following learning results			
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.  The students are able to design and evaluate navigation systems and robotic systems for medical applications.					
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.  The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Study T	ime 110, Study Time in Led	ture 70			
Credit points	6					
Course achievement	Yes 10 %	Form Presentation Written elaboration	Description			
Examination	Written exam					
Examination duration and scale	90 minutes					
Assignment for the	Computer Science: S	pecialisation II: Intelligence	Engineering: Elective Compulsory			
	International Manage Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen Product Developmen	ment and Engineering: Spilisation Intelligent Systems ng: Specialisation Artificial ng: Specialisation Implants ng: Specialisation Medical ng: Specialisation Manage t, Materials and Production t, Materials and Production	ecialisation II. Electrical Engineering: Electicalisation II. Process Engineering and Bios and Robotics: Elective Compulsory Organs and Regenerative Medicine: Electical English and Endoprostheses: Elective Compulsory Technology and Control Theory: Elective Compulsory Technology and Product Theory: Elective Computation: Elective	technology: Elective ve Compulsory fompulsory e Compulsory ctive Compulsory ulsory	Compulsory	
	·		: Specialisation Materials: Elective Compul ion Bio- and Medical Technology: Elective	•		

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

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

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

Module M1384: Case	Studies for Regenerative Med	icine and Tissue Engineering		
Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: Com	pulsory	
Following Curricula	Biomedical Engineering: Specialisation Impla	·	•	
	Biomedical Engineering: Specialisation Mana	•		
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective	Compulsory	

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

Module M0634: Introd	duction into Me	dical Technology a	nd Systems		
Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)			Lecture	2	3
Introduction into Medical Technolog	gy and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technolog	gy and Systems (L1876)		Recitation Section	on (large) 1	1
Module Responsible	Prof. Alexander Schlad	efer			
Admission Requirements	None				
Recommended Previous	principles of math (alg	gebra, analysis/calculus)			
Knowledge	principles of stochast	ics			
	principles of programi	ming, R/Matlab			
Educational Objectives	After taking part succ	essfully, students have read	hed the following learning resu	lts	
Professional Competence			<u> </u>		
Knowledge	The students can ex	plain principles of medical	technology, including imaging	systems, computer aide	d surgery, and medical
	information systems.	They are able to give an ov	erview of regulatory affairs and	standards in medical tech	nology.
G/ ///					
Skills	The students are able	to evaluate systems and m	edical devices in the context of	clinical applications.	
Personal Competence					
Social Competence	The students describe	a problem in medical tech	nology as a project, and define	tasks that are solved in a j	oint effort.
Autonomy	The students can refl	ast their knowledge and de	sumant the results of their we	rk. They can proceed the	roculto in an appropriate
Autonomy	manner.	ect their knowledge and do	cument the results of their wo	rk. They can present the r	esuits in an appropriate
	manner.				
Workload in Hours	Independent Study Ti	me 110, Study Time in Lect	ure 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
Formularitan	Yes 10 %	Presentation			
Examination					
Examination duration and scale	90 minutes				
Assignment for the	General Engineering	Science (German program	semester): Specialisation Bion	nedical Engineering: Comp	ulsony
Following Curricula			Software Engineering: Elective (		uisoi y
			and Engineering Science: Elect		
		ualification: Elective Compu		, , , ,	
	Electrical Engineering	: Core Qualification: Elective	e Compulsory		
	Engineering Science:	Specialisation Biomedical E	ngineering: Compulsory		
	General Engineering S	Science (English program, 7	semester): Specialisation Biom	edical Engineering: Compu	ılsory
	Computational Science	e and Engineering: Speciali	sation II. Mathematics & Engine	ering Science: Elective Co	mpulsory
	Biomedical Engineering	ng: Specialisation Artificial C	rgans and Regenerative Medici	ne: Elective Compulsory	
	_	• .	and Endoprostheses: Elective Co		
	_		echnology and Control Theory: I		
	_		ent and Business Administration		
	rechnomathematics:	Specialisation III. Engineerii	ng Science: Elective Compulsory	<u>'</u>	

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calaulua			
Knowledge	Calculus     Linear Algebra			
	<ul><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>			
	• Engineering Mechanics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the	ne following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able to reflect existing terms and conce	epts in Nonlinear Dynamics and to	develop and resea	arch new terms and
	concepts.			
Skills	Students are able to apply existing methods and proces	sures of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks ind	vidually and to identify and follow u	ıp novel research ta	sks by themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Electiv	ve Compulsory		
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	n Mechatronics: Elective Compulsor	У	
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and Ro			
	Biomedical Engineering: Specialisation Artificial Organs	•	e Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	•		
	Biomedical Engineering: Specialisation Management an		Compulsory	
	Product Development, Materials and Production: Core C	' '		
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

Course L0702: Nonlinear Dyn	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.	

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Courses				
Title		Тур	Hrs/wk	CP .
Semiconductor Technology (L0722) Semiconductor Technology (L0723)		Lecture Practical Course	4 2	4 2
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material scie	nce and semiconductor devices		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
<b>Professional Competence</b>				
Knowledge				
	Students are able			
	to describe and to explain current fab	ication techniques for Si and GaAs substrates	,	
	• to discuss in details the relevant	fabrication processes, process flows and	the impact thereof o	n the fabrication
	semiconductor devices and integrated circ	uits and		
	to present integrated process flows.			
	, , ,			
Skills				
	Students are capable			
	to analyze the impact of process para	meters on the processing results,		
	to select and to evaluate processes are	d		
	<ul> <li>to develop process flows for the fabric</li> </ul>	ation of semiconductor devices		
	to develop process nows for the labile	and of Schmedinactor acrises.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform	their lab experiments in team work as well as	to present and discus	es the results in fro
	of audience.	their lab experiments in team work as well as	to present and discu.	33 the results in the
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study Time in	Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanc	electronics and Microsystems Technology: Ele	ctive Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Art	ificial Organs and Regenerative Medicine: Elec	tive Compulsory	
		plants and Endoprostheses: Elective Compulso		
	3 3 1	dical Technology and Control Theory: Elective	, ,	
	Biomedical Engineering: Specialisation Ma Microelectronics and Microsystems: Core (	nagement and Business Administration: Electi	ve compuisory	

	or Technology
Тур	Lecture
Hrs/wk	4
Orkload in Hours	Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
Cycle	
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, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dama: annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kineti influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs)</li> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetical properties and oxide charges, film growth process, reaction kinetical properties and oxide charges, thermal oxidation, thermal oxidation gaAs)</li> </ul>
	temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technique APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacue vaporation, sputtering)  • Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximand projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique a electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electroeam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic a anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchi backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)  • Process integration (CMOS process, bipolar process)  • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical containing the bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
	o. Tilleringmann. Sinzidin-Halbiette technologie, Teabher Verlag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Course L0723: Semiconductor 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	

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
<b>Admission Requirements</b>	None			
<b>Recommended Previous</b>				
Knowledge	Introduction to control systems			
	Control theory and design			
	control and design			
<b>Educational Objectives</b>	After taking part successfully, students have rea	ched the following learning results		
<b>Professional Competence</b>				
Knowledge	Students can explain humanoid robots.			
	Students can explain numerical robots.     Students learn to apply basic control conditions.	epts for different tasks in humanoid r	obotics.	
Skills	Students acquire knowledge about selecter	ed aspects of humanoid robotics, base	ed on specified literature	
	Students generalize developed results and	d present them to the participants		
	<ul> <li>Students practice to prepare and give a p</li> </ul>	resentation		
Personal Competence				
Social Competence				
Social competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	They are able to provide appropriate feed	back and handle constructive criticisn	n of their own results	
Autonomy				
,	<ul> <li>Students evaluate advantages and drav</li> </ul>	backs of different forms of present	ation for specific tasks	and select the bes
	solution			
	Students familiarize themselves with a s	cientific field, are able of introduce it	and follow presentation	ns of other students
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lectu	ıre 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	, , , , , , , , , , , , , , , , , , , ,			
Following Curricula	Mechatronics: Specialisation System Design: Ele			
	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Implants	·	•	
	Biomedical Engineering: Specialisation Medical T	•		
	Biomedical Engineering: Specialisation Managen Theoretical Mechanical Engineering: Specialisati			
	Theoretical Mechanical Engineering: Specialisati	on nobotics and computer science: El	ective Compuisory	

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

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Courses					
Title		Тур	Hrs/wk	СР	
Linear and Nonlinear System Ident		Lecture	2	3	
Module Responsible					
Admission Requirements					
Recommended Previous	<ul> <li>Classical control (frequency res</li> </ul>	sponse, root locus)			
Knowledge	State space methods				
	Discrete-time systems				
	Linear algebra, singular value d	lecomposition			
	Basic knowledge about stochas	tic processes			
Educational Objections	After telling much acceptable wheeler	le company de la fallacción de la comica de contra			
Educational Objectives Professional Competence	Arter taking part successium, student	s have reached the following learning results			
Knowledge					
Knowieage	<ul> <li>Students can explain the gene</li> </ul>	eral framework of the prediction error method	and its application to a va	ariety of linear a	
	nonlinear model structures				
	They can explain how multilaye	er perceptron networks are used to model nonlin	near dynamics		
		ximate predictive control scheme can be based			
	They can explain the idea of subspace identification and its relation to Kalman realisation theory				
Skills					
		ing the predicition error method to the exper	imental identification of lir	near and nonline	
	models for dynamic systems				
	<ul> <li>They are capable of implementing a nonlinear predictive control scheme based on a neural network model</li> <li>They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic sys</li> <li>They can do the above using standard software tools (including the Matlab System Identification Toolbox)</li> </ul>				
	They can do the above using state	andard software tools (including the Matiab Sys	stem identification (oolbox)		
Personal Competence					
Social Competence	Students can work in mixed groups on	n specific problems to arrive at joint solutions.			
Autonomy	Students are able to find required info	ormation in sources provided (lecture notes, lite	rature software document	ation) and use it	
riaconomy	solve given problems.	mater in sources provided (rectare notes) inc		ation, and ase it	
Workload in Hours	1 2	me in Lecture 28			
Credit points					
Course achievement					
Examination					
Examination duration and	30 min				
scale					
_		Control and Power Systems Engineering: Electiv	e Compulsory		
Following Curricula	,	nt Systems and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System D		Tastiva Compulation		
		n Artificial Organs and Regenerative Medicine: E			
		n Implants and Endoprostheses: Elective Compu	•		
		n Medical Technology and Control Theory: Comp n Management and Business Administration: Ele	•		
	bioinculcal Engineering. Specialisation	n management and business Administration. Ele	Letive compuisory		

Course L0660: Linear and No	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>			

voaule MU840: Optin	nal and Robust Control				
ourses					
tle		Тур	Hrs/wk	СР	
otimal and Robust Control (L0658		Lecture	2	3	
ptimal and Robust Control (L0659	ı	Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Classical control (frequency response, root	locus)			
Knowledge	State space methods				
	<ul> <li>Linear algebra, singular value decomposition</li> </ul>	on			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results			
Professional Competence	meer taking pare succession, stadents have reac	nea the following feathing feeting			
Knowledge					
	Students can explain the significance of the				
	They can explain the duality between optin	·			
	They can explain how the H2 and H-infinity				
	They can explain how an LQG design proble     They can explain how model uncertainty a	·			
	<ul> <li>They can explain how model uncertainty c</li> <li>They can explain how - based on the smal</li> </ul>	,		3	
	an uncertain plant.	il gain theorem - a robust controller can gu	iarantee stability	and periormance	
	They understand how analysis and synthes	is conditions on feedback loops can be rep	esented as linear	matrix inequalitie	
				•	
Skills	Students are capable of designing and tuni	ng LQG controllers for multivariable plant n	nodels.		
	They are capable of representing a H2 or H			and of using stand	
	software tools for solving it.				
	<ul> <li>They are capable of translating time and f</li> </ul>	frequency domain specifications for contro	I loops into const	raints on closed-lo	
	sensitivity functions, and of carrying out a	mixed-sensitivity design.			
	They are capable of constructing an LFT in the capable of constructing and LFT in the capable of	uncertainty model for an uncertain systen	n, and of designir	ng a mixed-object	
	robust controller.				
	<ul> <li>They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using the LMI-solvers for solving them.</li> <li>They can carry out all of the above using standard software tools (Matlab robust control toolbox).</li> </ul>				
	• They can carry out all of the above using st	andard software tools (Matiab robust contr	or toolbox).		
Personal Competence					
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.				
Autonomy	Students are able to find required information in s	sources provided (lecture notes, literature,	software docume	ntation) and use it	
	solve given problems.				
Workload in Hours  Credit points	Independent Study Time 124, Study Time in Lectu 6	ure 56			
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Control and	, , , , ,	oulsory		
Following Curricula	3, ,				
	Aircraft Systems Engineering: Core Qualification: Elective Compulsory  Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory				
	Mechatronics: Specialisation System Design: Elect	' '			
Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory					
	Biomedical Engineering: Specialisation Implants a		,		
	Biomedical Engineering: Specialisation Medical Te	·	pulsory		
	Biomedical Engineering: Specialisation Manageme	•			
	Product Development, Materials and Production: S	Specialisation Product Development: Electiv	e Compulsory		
	Product Development, Materials and Production: S	Specialisation Production: Elective Compuls	ory		
	Product Development, Materials and Production: S	Specialisation Materials: Elective Compulsor	ТУ		
	Theoretical Mechanical Engineering: Core Qualific	ation: Elective Compulsory			

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

Title  Marketing of Innovations (L2009) PBL Marketing of Innovations (L0862)  Module Responsible Admission Requirements Recommended Previous Knowledge  Module International Business Basic understanding of business administ international business)	Typ  Lecture  Project-/problem-based Learn  tration principles (strategic planning d	Hrs/wk 4 ing 1	<b>CP</b>
Marketing of Innovations (L2009) PBL Marketing of Innovations (L0862)  Module Responsible Prof. Christian Lüthje  Admission Requirements None  Recommended Previous Knowledge  Module International Business Basic understanding of business administ	Lecture Project-/problem-based Learr	4	4
PBL Marketing of Innovations (L0862)  Module Responsible Prof. Christian Lüthje  Admission Requirements None  Recommended Previous Knowledge • Module International Business • Basic understanding of business administration	Lecture Project-/problem-based Learr		
Module Responsible Prof. Christian Lüthje  Admission Requirements None  Recommended Previous Knowledge  Module International Business  Basic understanding of business administ		ing 1	2
Admission Requirements  Recommended Previous Knowledge  Module International Business Basic understanding of business administ	tration principles (strategic planning d		2
Recommended Previous Knowledge  Module International Business Basic understanding of business administ	tration principles (strategic planning d		
<ul> <li>Module International Business</li> <li>Basic understanding of business administ</li> </ul>	tration principles (strategic planning d		
Basic understanding of business administration	tration principles (strategic planning d		
		ecision theory. r	project management.
	, , , , , , , , , , , , , , , , , , , ,	,	
Bachelor-level Marketing Knowledge (Market	ting Instruments, Market and Competitor	Strategies, Basics	of Buying Behavior)
Unerstanding the differences beweetn B2B a			
Understanding of the importance of managing			
Good English proficiency; presentation skills	i		
Educational Objectives After taking part successfully, students have reach	ed the following learning results		
Professional Competence			
Knowledge Students will have gained a deep understanding o	of		
Specific characteristics in the marketing of in	nnovative poroducts and services		
Approaches for analyzing the current market		ment	
The gathering of information about future cu	·		
Concepts and approaches to integrate lead of the concepts are concepts.	users and their needs into product and se	rvice developmer	t processes
Approaches and tools for ensuring customer	r-orientation in the development of new pr	oducts and innov	ative services
Marketing mix elements that take into const	sideration the specific requirements and	challenges of inn	ovative products and
services			
Pricing methods for new products and servic     The organization of complex sales forces and			
Communication concepts and instruments for			
Skills Based on the acquired knowledge students will be			
a Design and to evaluate designer regarding	marketing and innevation strategies		
Design and to evaluate decisions regarding     Analyze markets by applying market and ted			
Conduct forecasts and develop compelling s			
Translate customer needs into concepts, pr		cessfully apply a	dvanced methods for
customer-oriented product and service deve	elopment		
Use adequate methods to foster efficient difference of the di	fusion of innovative products and services	5	
Choose suitable pricing strategies and comm			
Make strategic sales decisions for products a		els)	
Apply methods of sales force management (	(i.e. customer value analysis)		
Personal Competence			
Social Competence The students will be able to			
have fruitful discussions and exchange argu	ments		
develop original results in a group			
present results in a clear and concise way			
carry out respectful team work			
Autonomy The students will be able to			
Acquire knowledge independently in the spe	ecific context and to map this knowledge o	on other new com	plex problem fields.
Consider proposed business actions in the fi	eld of marketing and reflect on them.		
Workload in Hours Independent Study Time 110, Study Time in Lectur	re 70		
Credit points 6			
Course achievement None			
<b>Examination</b> Subject theoretical and practical work			
Examination duration and Written elaboration, excercises, presentation, oral	participation		
scale			
Assignment for the Global Technology and Innovation Management &	·		
Following Curricula International Management and Engineering: Special			
Mechanical Engineering and Management: Speciali Biomedical Engineering: Specialisation Artificial Or			
Biomedical Engineering: Specialisation Artificial Organical Engineering: Specialisation Implants an		Compuisory	
Biomedical Engineering: Specialisation Medical Tec		npulsory	
Biomedical Engineering: Specialisation Managemen			

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

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

Module M1143: Applie	ed Design Methodology in Mechatronics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Med	chatronics (L1523)	Lecture	2	2
Applied Design Methodology in Med	chatronics (L1524)	Project-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous	Basics of mechanical design, electrical design or computer-s	sciences		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the fol	lowing learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product design of	onsidering targeted application of sp	ecific product	design techniques
Skills	Creative handling of processes used for scientific preparatio	n and formulation of complex produ	ct design prob	olems / Application of
	various product design techniques following theoretical aspe	ects.		
B				
Personal Competence	Students will salve and execute technical scientific tacks	from an industrial contact in small	decian teams	with application of
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.			
Autonomy	Students are enabled to optimize the design and developme	ant process asserting to the target a	nd tonic of the	docian
-	Independent Study Time 110, Study Time in Lecture 70	the process according to the target a	na topic of the	: design
Credit points	, ,			
Course achievement				
	Subject theoretical and practical work			
	30 min Presentation for a group design-work			
scale	group design work			
	International Management and Engineering: Specialisation II	. Product Development and Producti	on: Elective Co	ompulsory
Following Curricula	International Management and Engineering: Specialisation II	·		5pa.55.y
	Mechanical Engineering and Management: Specialisation Pro			ulsory
	Mechatronics: Specialisation System Design: Elective Compu	•		,
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endopr	ostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology a	and Control Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Management and Bu	siness Administration: Elective Comp	oulsory	
	Theoretical Mechanical Engineering: Specialisation Product [	Development and Production: Electiv	e Compulsory	

Course L1523: Applied Design Methodology in Mechatronics		
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>	
Literature	<ul> <li>Definition folgt</li> <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: Applied Design Methodology in Mechatronics	
Тур	Project-/problem-based Learning
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", module "fu	ndamentals for process engineering"		
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence	, , , , , , , , , , , , , , , , , , ,			
•	Students are able to describe the basic concep	its of bioprocess engineering. They are able to	classify differen	t types of kinetics f
	enzymes and microorganisms, as well as to			
	rheology can be named and mass transport	**		-
	fundamental bioprocess management, steriliza	·		
Skills	After successful completion of this module, stu	dents should be able to		
	<ul> <li>describe different kinetic approaches for</li> </ul>	growth and substrate-uptake and to calculate	the corresponding	ng parameters
	<ul> <li>predict qualitatively the influence of en</li> </ul>	nergy generation, regeneration of redox equ	ivalents and grow	wth inhibition on t
	fermentation process			
	<ul> <li>analyze bioprocesses on basis of stoichion</li> </ul>	ometry and to set up / solve metabolic flux eq	uations	
	<ul> <li>distinguish between scale-up criteria for</li> </ul>	different bioreactors and bioprocesses (anae	robic, aerobic as	well as microaerob
	to compare them as well as to apply the	'		
	<ul> <li>propose solutions to complicated biotech</li> </ul>	nnological problems and to deduce the corresp	onding models	
	<ul> <li>to explore new knowledge resources and</li> </ul>	to apply the newly gained contents		
	<ul> <li>identify scientific problems with concrete</li> </ul>			
	to document and discuss their procedure	es as well as results in a scientific manner		
Personal Competence				
Social Competence	· · ·			
	take position to their own opinions and increas	e their capacity for teamwork in engineering a	nd scientific envi	ronments.
Autonomy	After completion of this module participants w	ill be able to solve a technical problem in a te	am independentl	v bv organizing the
Ź	workflow and to present their results in a plen		·	, , , ,
	Independent Study Time 96, Study Time in Lec	ture 84		
Credit points		Description		
Course achievement	Compulsory Bonus Form Yes 5 % Subject theoretical	<b>Description</b> and		
	practical work			
Examination	Written exam			
Examination duration and	90 min			
scale				
	0 15 1 1 61 10			
Assignment for the	General Engineering Science (German program			
Following Curricula	General Engineering Science (German program		ieering: Compulso	ory
	Bioprocess Engineering: Core Qualification: Cor	, ,	Compulsor	
	Green Technologies: Energy, Water, Climate: S	•		
	Biomedical Engineering: Specialisation Artificia Biomedical Engineering: Specialisation Implant		o y	
	Biomedical Engineering: Specialisation Implant		nulsory	
	Biomedical Engineering: Specialisation Medical			
	Technomathematics: Specialisation III. Enginee		paisoi y	
		J		

Course L0841: Bioprocess Engineering - Fundamentals		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Andreas Liese	
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>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-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	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012  H. Chmiel: Bioprozeßtechnik, Elsevier, 2006  R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010  H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997  P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013	

Course L0842: Bioprocess En	ourse 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	
Language	DE	
Cycle	SoSe	
Content	1. Introduction (Prof. Liese, Prof. Zeng)	
	2. Enzymatic kinetics (Prof. Liese)	
	3. Stoichiometry I + II (Prof. Liese)	
	4. Microbial Kinetics I+II (Prof. Zeng)	
	5. Rheology (Prof. Liese)	
	6. Mass transfer in bioprocess (Prof. Zeng)	
	7. Continuous culture (Chemostat) (Prof. Zeng)	
	8. Sterilisation (Prof. Zeng)	
	9. Downstream processing (Prof. Liese)	
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)	
Literature	siehe Vorlesung	

Course L0843: Bioprocess 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 M1277: MED I	: Introduction to Anatomy
Courses	
Title	Typ Hrs/wk CP
Introduction to Anatomy (L0384)	Lecture 2 3
Module Responsible	Prof. Udo Schumacher
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system.
	The students can describe the basic macroscopy and microscopy of those systems.
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; the
	can explain the relevance of structures and their functions in the context of widespread diseases.
Personal Competence	
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui
	the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
	90 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	Compulsory
	Data Science: Specialisation Medicine: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory  Technometrics: Specialisation III. Engineering Science: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

L0384: Introduction t		
Тур		
Hrs/wk		
	3	
	Independent Study Time 62, Study Time in Lecture 28	
	r Prof. Tobias Lange	
Language	SoSe	
	t General Anatomy	
Content	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	
	7 <sup>th</sup> week: Genito-urinary System  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/Michael Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016	

Courses				
Courses				
<b>Title</b> Introduction to Physiology (L0385)		<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
	Dr. Beger Zimmermann	Lecture	2	3
Module Responsible	-			
Admission Requirements				
Recommended Previous Knowledge	None			
	After taking part successfully, students have reacl	and the following learning results		
Professional Competence	After taking part successivily, students have reach	led the following learning results		
•	The students can			
Knowicage	The students can			
	<ul> <li>describe the basics of the energy metabolis</li> </ul>	sm;		
	describe physiological relations in selected	fields of muscle, heart/circulation, r	neuro- and sensory physic	logy.
Skills	The students can describe the effects of basic boo	dily functions (sensory, transmission	n and processing of inforn	nation, developme
	of forces and vital functions) and relate them to si		, , , , , , , , , , , , , , , , , , ,	, , , , , , , , , , , , , , , , , , , ,
Personal Competence		•		
Social Competence	The students can conduct discussions in research	and medicine on a technical level.		
	The students can find solutions to problems in the	field of physiology, both analytical	and metrological.	
Autonomy	'	rising in the course and other phys	siological areas, using tec	chnical literature,
	themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lectur	e 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German program, 7	semester): Specialisation Biomedic	cal Engineering: Compulso	ory
Following Curricula	General Engineering Science (German program	n, 7 semester): Specialisation Me	echanical Engineering, F	ocus Biomechanio
	Compulsory			
	Data Science: Specialisation Medicine: Compulsor			
	Electrical Engineering: Specialisation Medical Tech			
	Engineering Science: Specialisation Biomedical En			Di
	General Engineering Science (English program Compulsory	, / semester): Specialisation Me	echanicai Engineering, F	ocus Biomechanii
	General Engineering Science (English program, 7	semester). Specialisation Biomedic	al Engineering: Compulsor	7/
	General Engineering Science (English program, 7:	•		-
	Mechanical Engineering: Specialisation Biomechan	•	a. angineering. Elective et	pui301 y
	Biomedical Engineering: Specialisation Medical Te		ive Compulsory	
	Biomedical Engineering: Specialisation Manageme	•		
	Biomedical Engineering: Specialisation Artificial O			
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Elective Compu	ulsory	

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

Module M1278: MED	l: Introduction to Radiology and Radiation Therapy
Courses	
Title	Typ Hrs/wk CP
Introduction to Radiology and Radio	
Module Responsible	
Admission Requirements  Recommended Previous	
Knowledge	Note
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).
	The students can describe the patients' passage from their initial admittance through to follow-up care.
	Diagnostics
	The students can illustrate the technical base concepts of projection radiography, including 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 treatment method depending on the patient's clinical history and needs.
	The student can explain the influence of technical errors on the imaging techniques.
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	Therapy
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.
	The students can use the therapeutic principle (effects vs adverse effects)
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).
	Diagnostics
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	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	
Examination Examination duration and	Written exam
examination duration and scale	20 minutes
Assignment for the Following Curricula	
	Data Science: Specialisation Medicine: Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1335: BIO II	: Artificial Joint Replacement			
Courses				
Title	Ту	р	Hrs/wk	СР
Artificial Joint Replacement (L1306)	Le	cture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is recommer	nded.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following I	earning results		
Professional Competence				
Knowledge	The students can name the different kinds of artificial limbs.			
CI-311-	The students are supplied the set of the set			
SKIIIS	The students can explain the advantages and disadvantages of diffe	erent kinds of endoprotheses.		
Personal Competence				
Social Competence	The students are able to discuss issues related to endoprothese with	n student mates and the teach	ers.	
	The desired section of the terror of the formation of the first of the terror of the t			
Autonomy	The students are able to acquire information on their own. They can	also judge the information wil	in respect to its	credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Specialisation II. Proces	s Engineering and Biotechnolo	gy: Elective Cor	mpulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid Materials: Elective	e Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regene	rative Medicine: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthese	s: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Con	trol Theory: Elective Compulso	ory	
	Biomedical Engineering: Specialisation Management and Business A	dministration: Elective Compu	Isory	
	Orientation Studies: Core Qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical	Technology: Elective Compuls	ory	

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

Module M0845: Feedl	oack Control in Medical Techno	ology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	e reached the following learning results		
<b>Professional Competence</b>				
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.			
	Internal control loops of the human body example in for anesthesia control.	will be discussed in the same way like the	design of external cl	osed loop system fo
	The handling of PID controllers and mode illustrated. The operation of simple equivale	rn controller like predictive controller or fu ent circuits will be discussed.	zzy controller or neu	ral networks will be
Skills	Application of modeling, identification, conti	rol technology in the field of medical technolo	ogy.	
Personal Competence				
Social Competence	Students can develop solutions to specific p	roblems in small groups and present their res	sults	
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 I	Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Medica	al Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Contro	ol and Power Systems Engineering: Elective Co	ompulsory	
		ants and Endoprostheses: Elective Compulsor	-	
		icial Organs and Regenerative Medicine: Elect		
		agement and Business Administration: Electiv		
	Biomedical Engineering: Specialisation Medi	ical Technology and Control Theory: Compuls	ory	

Course L0664: Feedback Con	itrol in Medical Technology
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows:
	<ul> <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> <li>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.</li> </ul>
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>

Courses				
Γitle	Тур		Hrs/wk	СР
Advanced Topics in Control (L0661		re	2	3
Advanced Topics in Control (L0662	) Recita	ation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequa	alities		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the following lear	ning results		
Professional Competence				
Knowledge Skills	<ul> <li>Students can explain the advantages and shortcomings of the cl</li> <li>They can explain the representation of nonlinear systems in the</li> <li>They can explain how stability and performance conditions for Ll</li> <li>They can explain how gridding techniques can be used to solve a</li> <li>They are familiar with polytopic and LFT representations of I associated with each of these model structures</li> <li>Students can explain how graph theoretic concepts are used systems</li> <li>They can explain the convergence properties of first order conse</li> <li>They can explain analysis and synthesis conditions for formation</li> <li>Students can explain concepts behind linear and qLPV Model Pre</li> </ul>	form of quasi-LPV syst PV systems can be forr analysis and synthesis LPV systems and som If to represent the co ensus protocols a control loops involving dictive Control (MPC) If carry out a mixed- models lbox) for these tasks	ems mulated as LMI co problems for LPV ne of the basic s mmunication topo g either LTI or LPV sensitivity design	systems  ynthesis techniqu  ology of multiage  agent models  of gain-schedul
	Students can design MPC controllers for linear and non-linear system	stems using Matlab too	ols	
Personal Competence				
	Students can work in small groups and arrive at joint results.			
Autonomy				
,	given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the		eering: Elective Comp	ulsory	
Following Curricula		-i Florido Como d		
	International Management and Engineering: Specialisation II. Mechatro	nics: Elective Compuls	ory	
	Mechatronics: Specialisation System Design: Elective Compulsory	Compulsor:		
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective			
	Biomedical Engineering: Specialisation Implants and Endoprostheses: E		nulcan.	
	Biomedical Engineering: Specialisation Medical Technology and Control			
	Biomedical Engineering: Specialisation Management and Business Adm			
	Biomedical Engineering: Specialisation Artificial Organs and Regenerati	uter Science: Elective (		

Course L0661: Advanced 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	Linear Parameter-Varying (LPV) Gain Scheduling	
	- Linearizing gain scheduling, hidden coupling	
	- Jacobian linearization vs. quasi-LPV models	
	- Stability and induced L2 norm of LPV systems	
	- Synthesis of LPV controllers based on the two-sided projection lemma	
	- Simplifications: controller synthesis for polytopic and LFT models	
	- Experimental identification of LPV models	
	- Controller synthesis based on input/output models	
	- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator	
	Control of Multi-Agent Systems	
	- Communication graphs	
	- Spectral properties of the graph Laplacian	
	- First and second order consensus protocols	
	- Formation control, stability and performance	
	- LPV models for agents subject to nonholonomic constraints	
	- Application: formation control for a team of quadrotor helicopters	
	Linear and Nonlinear Model Predictive Control based on LMIs	
Literature	Morpor H. Locture Notes "Advanced Topics in Control"	
	Werner, H., Lecture Notes "Advanced Topics in Control"     Selection of relevant received pages made available as add decuments via Studio.	
	Selection of relevant research papers made available as pdf documents via StudIP	

Course L0662: Advanced Top	ourse L0662: Advanced Topics in Control	
Тур	Recitation Section (small)	
Hrs/wk	2	
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	

Courses					
Title			Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and			Lecture	3	5
Bioelectromagnetics: Principles and	1		Recitation Section (small)	2	1
•	Prof. Christian Schuster				
Admission Requirements	Basic principles of physics				
Knowledge					
Educational Objectives	After taking part successfully, stud	ents have reached the followi	ing learning results		
Professional Competence			<u> </u>		
Knowledge	Students can explain the basic prin	nciples, relationships, and me	thods of bioelectromagnetics,	i.e. the quantific	ation and applicatio
	of electromagnetic fields in biolog	ical tissue. They can define	and exemplify the most impo	ortant physical ph	nenomena and orde
	them corresponding to wavelengt				
	techniques for characterization of	,		n give examples	for therapeutic an
	diagnostic utilization of electromag	gnetic fields in medical techno	ology.		
Skills	Students know how to apply variou	us methods to characterize th	e behavior of electromagnetic	fields in biologic	al tissue. In order t
	do this they can relate to and ma				
	important effects that these mode	•	·	•	
	frequency, respectively, and they	can analyze them in a quanti	itative way. They are able to o	develop validation	n strategies for thei
	predictions. They are able to evalu	ate the effects of electromag	netic fields for therapeutic an	d diagnostic appli	cations and make a
	appropriate choice.				
Personal Competence					
Social Competence	Students are able to work togethe English (e.g. during small group ex	•	small groups. They are able	to present their	results effectively i
	Linglish (e.g. during small group ex	ercises).			
Autonomy	Students are capable to gather in	nformation from subiect rela	ated, professional publication	s and relate tha	t information to th
,	context of the lecture. They are al	•	·		
	other lectures (e.g. theory of elec	ctromagnetic fields, fundame	entals of electrical engineerin	g / physics). The	y can communicat
	problems and effects in the field of	f bioelectromagnetics in Engli	sh.		
	Independent Study Time 110, Stud	ly Time in Lecture 70			
Credit points		Description			
Course achievement	Yes None Presentation				
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialisation	on Microwaya Engineering O	ntics and Flectromagnetic Co	mnatihility: Flooti	ve Compulsory
Following Curricula			_	impatibility: Electi	ve Compuisory
. onowing curricula	International Management and Eng			Compulsorv	
	Biomedical Engineering: Specialisa				
	Biomedical Engineering: Specialisa			-	
	Biomedical Engineering: Specialisa	tion Artificial Organs and Reg	enerative Medicine: Elective (	Compulsory	
	Biomedical Engineering: Specialisa	tion Medical Technology and	Control Theory: Elective Com	pulsory	
	Theoretical Mechanical Engineering	g: Specialisation Bio- and Med	lical Technology: Elective Con	npulsory	

Course L0371: Bioelectromag	gnetics: Principles and Applications
Тур	Lecture
Hrs/wk	
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
Content	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

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

## **Specialization Medical Technology and Control Theory**

Module M0623: Intell	igent Systems in Medicine			
Courses				
<b>Title</b> Intelligent Systems in Medicine (L0 Intelligent Systems in Medicine (L0	334)	<b>Typ</b> Lecture Project Seminar	Hrs/wk 2 2	<b>CP</b> 3 2
Intelligent Systems in Medicine (L0		Recitation Section (small)	1	1
Admission Requirements	Prof. Alexander Schlaefer  None			
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus     principles of stochastics     principles of programming, Java/C++ and R/I     advanced programming skills			
<b>Educational Objectives</b>	After taking part successfully, students have reache	ed the following learning results		
Professional Competence  Knowledge	The students are able to analyze and solve clinica optimization, and planning. They are able to explain clinical contexts. The students can compare differing the context of clinical data and explain challeng and safety requirements.	n methods for classification and their respo erent methods for representing medical kn	ective advantage owledge. They c	es and disadvantages an evaluate methods
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.			
,	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.  The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate			
Workload in Hours	manner.  Independent Study Time 110, Study Time in Lecture	e 70		
Credit points				
Course achievement	Compulsory Bonus Form Yes 10 % Presentation Yes 10 % Written elaboration	Description		
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	, ,	nology: Elective Compulsory utational Methods in Biomedical Imaging: 0 d Robotics: Elective Compulsory gans and Regenerative Medicine: Elective 0 d Endoprostheses: Elective Compulsory thnology and Control Theory: Elective Computer of the	Compulsory oulsory mpulsory	

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

Course L0333: Intelligent 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

Experimental Methods in Biomechanics (L0377)  Experimental Methods for the Characterization of Mate Numerical Methods in Biomechanics (L1583)  Seminar Biomedical Engineering (L1890)  Fluid Mechanics II (L0001)  System Simulation (L1820)  System Simulation (L1821)  Ceramics Technology (L0379)  Module Responsible  Admission Requirements  Recommended Previous  Knowledge  Educational Objectives  Professional Competence  Knowledge  Skills  Personal Competence  Social Competence  Autonomy  Workload in Hours  Depends on choice Credit points  6				
Nature's Hierarchical Materials (L1663) Introduction to Waveguides, Antennas, and Electroma Introduction to Waveguides, Antennas, and Electroma Development and Regulatory Approval of Medical Dev Experimental Methods in Biomechanics (L0377) Experimental Methods for the Characterization of Materical Methods in Biomechanics (L1583) Seminar Biomedical Engineering (L1890) Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Prof. Michael Mo Admission Requirements None  Recommended Previous Knowledge Educational Objectives After taking part Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choi				
Introduction to Waveguides, Antennas, and Electroma Introduction to Waveguides, Antennas, and Electroma Development and Regulatory Approval of Medical Dev Experimental Methods in Biomechanics (L0377) Experimental Methods for the Characterization of Mate Numerical Methods in Biomechanics (L1583) Seminar Biomedical Engineering (L1890) Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Prof. Michael Mo Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choi		Тур	Hrs/wk	СР
Introduction to Waveguides, Antennas, and Electroma Development and Regulatory Approval of Medical Dev Experimental Methods in Biomechanics (L0377) Experimental Methods for the Characterization of Mate Numerical Methods in Biomechanics (L1583) Seminar Biomedical Engineering (L1890) Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Prof. Michael Mo Admission Requirements None  Recommended Previous Knowledge Educational Objectives After taking part Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choi Credit points 6		Seminar	2	3
Development and Regulatory Approval of Medical Development and Regulatory Approval of Medical Development and Regulatory Approval of Medical Development and Methods in Biomechanics (L0377)  Experimental Methods for the Characterization of Mate Numerical Methods in Biomechanics (L1583)  Seminar Biomedical Engineering (L1890)  Fluid Mechanics II (L0001)  System Simulation (L1820)  System Simulation (L1821)  Ceramics Technology (L0379)  Module Responsible  Admission Requirements  Knowledge  Educational Objectives  After taking part  Professional Competence  Knowledge  Skills  Personal Competence  Social Competence  Autonomy  Workload in Hours  Depends on choice Credit points  6	netic Compatibility (L1669)	Lecture	3	4
Experimental Methods in Biomechanics (L0377) Experimental Methods for the Characterization of Material Methods in Biomechanics (L1583) Eminar Biomedical Engineering (L1890) Eluid Mechanics II (L0001) Eystem Simulation (L1820) Eystem Simulation (L1821) Erramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choice Credit points  Credit points	netic Compatibility (L1877)	Recitation Section (small)	2	2
Experimental Methods for the Characterization of Materian Methods in Biomechanics (L1583)  Seminar Biomedical Engineering (L1890)  Fluid Mechanics II (L0001)  System Simulation (L1820)  System Simulation (L1821)  Ceramics Technology (L0379)  Module Responsible  Admission Requirements  Recommended Previous  Knowledge  Educational Objectives  After taking part  Professional Competence  Knowledge  Skills  Personal Competence  Social Competence  Autonomy  Workload in Hours  Depends on choi  Credit points	ces (L1588)	Lecture	2	3
Numerical Methods in Biomechanics (L1583) Seminar Biomedical Engineering (L1890) Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives After taking part Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choi Credit points		Lecture	2	3
Seminar Biomedical Engineering (L1890) Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge  Educational Objectives After taking part  Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy  Workload in Hours Depends on choi Credit points	rials (L1580)	Lecture	2	3
Fluid Mechanics II (L0001) System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge  Educational Objectives After taking part  Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy  Workload in Hours Depends on choi		Seminar	2	3
System Simulation (L1820) System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choice Credit points  6		Seminar	2	3
System Simulation (L1821) Ceramics Technology (L0379)  Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choice Credit points		Lecture	2	4
Module Responsible Prof. Michael Mo Admission Requirements None  Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choi Credit points  Porf. Michael Mo None After taking part  After taking part  Depends on choi 6		Lecture	2	2
Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choice Credit points  None None None None None None None Non		Recitation Section (large)	1	2
Admission Requirements Recommended Previous Knowledge  Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Depends on choice Credit points  Recommends After taking part After taking part Depends on choice 6		Lecture	2	3
Recommended Previous Knowledge  Educational Objectives After taking part  Professional Competence Knowledge Skills  Personal Competence Social Competence Autonomy  Workload in Hours Credit points 6	lock			
Knowledge  Educational Objectives After taking part  Professional Competence  Knowledge Skills  Personal Competence Social Competence Autonomy  Workload in Hours  Credit points  6				
Educational Objectives Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points 6				
Professional Competence  Knowledge Skills  Personal Competence Social Competence Autonomy  Workload in Hours Credit points 6				
Knowledge Skills Personal Competence Social Competence Autonomy Workload in Hours Credit points 6	successfully, students have reached	the following learning results		
Skills  Personal Competence Social Competence Autonomy  Workload in Hours Depends on choi  Credit points 6				
Personal Competence Social Competence Autonomy Workload in Hours Depends on choi Credit points 6				
Social Competence Autonomy  Workload in Hours Depends on choi  Credit points 6				
Social Competence Autonomy  Workload in Hours Depends on choi  Credit points 6				
Autonomy  Workload in Hours Depends on choi  Credit points 6				
Workload in Hours Depends on choi Credit points 6				
Credit points 6	ce of courses			
Assignment for the Biomedical Engir				
		ndoprostheses: Elective Compulsory		
	eering: Specialisation Implants and E	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory		
		ology and Control Theory: Elective Comp	Juisory	
Biomedical Engir	eering: Specialisation Medical Techno	ology and Control Theory: Elective Comp nd Business Administration: Elective Co	-	

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

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

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

Course L1588: Development	and Regulatory Approval of Medical Devices
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<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 L0377: Experimental	Methods in Biomechanics	
Тур	Lecture	
Hrs/wk	2	
СР		
Workload in Hours	pendent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content		
Literature	Wird in der Veranstaltung bekannt gegeben	

Course L1580: Experimental	Methods for the Characterization of Materials		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Examination Form	lausur		
Examination duration and	90 min		
scale			
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber		
Language	DE		
Cycle	WiSe		
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 Me	thods in Biomechanics
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<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 Biom	ourse L1890: Seminar Biomedical Engineering		
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Referat		
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

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

Course L1820: System Simul	ation	
Тур	Lecture	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Dr. Stefan Wischhusen	
Language	DE	
Cycle	WiSe	
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  • Instruction and modelling of physical processes  • Modelling and limits of model  • Time constant, stiffness, stability, step size  • Terms of object orientated programming  • Differential equations of simple systems  • Introduction into Modelica  • Introduction into simulation tool  • Example: Hydraulic systems and heat transfer  • Example: System with different subsystems	
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>	

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

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

Module M0775: Ergon	nomics			
Courses				
Title		Тур	Hrs/wk	СР
Ergonomics (L0653)		Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have re	ached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 62, Study Time in Lec	ture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering: Sp	ecialisation II. Product Development and	Production: Elective Co	ompulsory
Following Curricula	Biomedical Engineering: Specialisation Implant	s and Endoprostheses: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Artificia	Organs and Regenerative Medicine: Ele	ctive Compulsory	
	Biomedical Engineering: Specialisation Manage			
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective	e Compulsory	

Course L0653: Ergonomics	urse L0653: Ergonomics	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Dr. Armin Bossemeyer	
Language	DE	
Cycle	WiSe	
Content		
Literature		

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	1 Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have r	reached the following learning results		
<b>Professional Competence</b>				
	(goals, utilities, environments). They can desc can be discussed in terms of decision proble world scenarios, students can summarize how formalism in static and dynamic settings. In settings, with and with complete access to t solving (partially observable) Markov decision Students can identify techniques for simultar desired states. Students can explain coordina of equilibria, social choice functions, voting pr Students can select an appropriate agent an students can derive decision trees and apply networks/dynamic Bayesian networks and a different sampling techniques for simplified a best action or policies for concrete settings. I	define intelligence in terms of rational behavior cribe the main features of environments. The notems and algorithms for solving these problems. We Bayesian networks can be employed as a known addition, students can define decision making the state of the environment. In this context, on problems, and they can recall techniques for neous localization and mapping, and can explait to problems and decision making in a multi-action of the context of the environment. In this context, on problems, and they can recall techniques for neous localization and mapping, and can explait the problems and decision making in a multi-action problems and decision making in a multi-action problems and decision making techniques. For those application scenarios of the problems and complex decision multi-agent situations students will apply different voting the problems are students will apply different voting the problems are students will apply different voting the problems.	otion of adversaria. For dealing with owledge represent procedures in sistudents can destructed at the control of the control	al agent cooperate uncertainty in restation and reason mple and sequencribe techniques value of informatiniques for achieverm of different typed agent applicated as or create Bayes on name and applicts can compute g different equilit
Personal Competence				
Social Competence	Students are able to discuss their solutions to	problems with others. They communicate in En	glish	
4				
Autonomy	students are able of checking their understan	iding of complex concepts by solving varaints of	concrete problen	115
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
	6			
Credit points				
Credit points Course achievement	None			
Course achievement	None Written exam			
Course achievement	Written exam			
Course achievement Examination	Written exam			
Course achievement Examination Examination duration and	Written exam 90 minutes	ce Engineering: Elective Compulsory		
Course achievement Examination Examination duration and scale	Written exam 90 minutes  Computer Science: Specialisation II: Intelligen	ice Engineering: Elective Compulsory Specialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam 90 minutes  Computer Science: Specialisation II: Intelligen	Specialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent System	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective (		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implant	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective Conts and Endoprostheses: Elective Compulsory	Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cour Mechatronics: Specialisation Intelligent Syster Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implan Biomedical Engineering: Specialisation Medical	Specialisation II. Information Technology: Elective rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective (	Compulsory	

Typ	Lecture		
	2		
	4		
_	Independent Study Time 92, Study Time in Lecture 28		
	ainer Marrone		
	N		
Cycle			
Content	WISC		
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, Minimax algorithm, alpha-beta pruning, elements of chance</li> <li>Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, productive, Bayes rule, full joint probability 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 by enumeration), typical-cas 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, dynamic Bayesian networks, Marko 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: sequential decision problems, value iteration, policy iteration, MDPs Decisions: sequential decision problems, value iteration, policy iteration, MDPs 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, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechani</li></ul>		
	mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwai Theorem		
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> </ol>		
	3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridg University Press, 2009		

Course L0512: Intelligent Au	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 M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
<b>Admission Requirements</b>	None			
Recommended Previous Knowledge	<ul><li>Calculus</li><li>Linear Algebra</li><li>Engineering Mechanics</li></ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached th	e following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able to denote terms and concepts of Vibra	ation Theory and develop them furt	her.	
Skills	Students are able to denote methods of Vibration Theor	y and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research task	s in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulsor			
Following Curricula	International Management and Engineering: Specialisati	on II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisatio	n Mechatronics: Elective Compulso	ry	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs	-		
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technology	•		
	Biomedical Engineering: Specialisation Management and		Compulsory	
	Product Development, Materials and Production: Core Q			
	Naval Architecture and Ocean Engineering: Core Qualification	• •		
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

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

Courses				
itle		Тур	Hrs/wk	СР
echnology Management (L0849)		Lecture	3	3
echnology Management Seminar		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous	Bachelor knowledge in business management			
Knowledge				
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence	Children will ask dans insights into			
кпошеаде	Students will gain deep insights into:			
	<ul> <li>International R&amp;D-Management</li> </ul>			
	<ul> <li>Technology Timing Strategies</li> </ul>			
	<ul> <li>Technology Strategies and Lifecycle M</li> </ul>	anagement (I/II)		
	<ul> <li>Technology Intelligence and Planning</li> </ul>			
	Technology Portfolio Management			
	Technology Portfolio Methodology	_		
	<ul> <li>Technology Acquisition and Exploitation</li> </ul>	n		
	<ul><li>IP Management</li><li>Organizing Technology Development</li></ul>			
	Technology Organization & Manageme	nt		
	Technology Funding & Controlling			
Skills	The course aims to:			
	Develop an understanding of the importance			
	Equip students with an understanding or	important elements of Technology Mar	agement (str	ategic, operation
	organizational and process-related aspects)	in a suithing the diagram time and a suit of the suit	- Tbl 1	4
	Foster a strategic orientation to problem-sol     importance for corporate strategy.	ving within the innovation process as well as	s lechnology is	nanagement and
	<ul><li>importance for corporate strategy</li><li>Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation)</li></ul>			
	Strengthen essential communication skills a			and financial issu
	concerning Technology-, Innovation- and R&I			aaac.a. 1550
	Bud and a substitution of the state of the s	the control of the barbar DCD and the		
	Basic concepts, models and tools, relevant to		novation	
	<ul> <li>Innovation as a process (steps, activities and</li> </ul>	results)		
Personal Competence				
Social Competence				
	<ul><li>Interact within a team</li><li>Raise awareness for globabl issues</li></ul>			
	- Raise awareness for globable issues			
Autonomy	Gain access to knowledge sources			
	<ul> <li>Discuss recent research debates in the conte</li> </ul>	xt of Technology and Innovation Managemen	t	
	Develop presentation skills	at or reclinology and innovation managemen		
	Discussion of international cases in R&D-Man	agement		
		-9		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	2 70		
Credit points				
Course achievement	None Written even			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the	Global Innovation Management: Core Qualification:	Compulsory		
Following Curricula	International Management and Engineering: Special	, ,	nnulsory	
. oo.amig curricula	Mechanical Engineering and Management: Specialis	•	pui30i y	
	Biomedical Engineering: Specialisation Artificial Org		npulsory	
	Biomedical Engineering: Specialisation Implants and		. ,	
	Biomedical Engineering: Specialisation Medical Tech		sory	
	Biomedical Engineering: Specialisation Managemen	t and Business Administration: Compulsory		

Course L0849: Technology M	lanagement
Тур	Lecture
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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011

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

Courses					
Title			Typ Lecture	Hrs/wk 2	<b>CP</b> 4
Microsystems Technology (L0724) Microsystems Technology (L0725)			Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu		, .,		
Admission Requirements	None				
Recommended Previous	Basics in physics, chemistry, mechanics	and semiconductor tec	hnology		
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students	nave reached the follow	ring learning results		
<b>Professional Competence</b>					
Knowledge	Students are able				
	<ul> <li>to present and to explain current</li> </ul>	fabrication techniques	for microstructures and especia	lly methods for	or the fabrication
	microsensors and microactuators, as we			•	
	to explain in details operation princ	nles of microsensors an	ad microactuators and		
	to explain in details operation princ	pies of filicroselisors an	id microactuators and		
	to discuss the potential and limitati	on of microsystems in a	pplication.		
Skills	Students are capable				
SKIIIS	Students are capable				
	to analyze the feasibility of microsy	stems,			
	to develop process flows for the fab	rication of microstructu	res and		
	to apply them				
	to apply them.				
Personal Competence					
Social Competence					
	Students are able to prepare and perfor	m their lab experiments	s in team work as well as to prese	ent and discus	s the results in fro
	of audience.	•	•		
Autonomy	None				
Workload in Hours	Independent Study Time 124, Study Tin	e in Lecture 56			
Credit points	6				
Course achievement	Compulsory Bonus Form	Description			
	Yes None Subject theore		n führen in Kleingruppen ein La		
	practical work	·	und diskutiert die Theorie sowie	die Ergebniise	ihrer Labortätigke
		vor dem ges	samten Kurs.		
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Na			mpulsory	
Following Curricula	Electrical Engineering: Specialisation Me				
	International Management and Enginee Biomedical Engineering: Specialisation I				
	Biomedical Engineering: Specialisation I			sorv	
	Biomedical Engineering: Specialisation I				
	Biomedical Engineering: Specialisation	•	·	-	
	Microelectronics and Microsystems: Cor	Ouglification, Flactive	Compulsory		

0724: Microsystems	
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-generatilithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; C 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 technique plasma processes, dry etching: back sputtering, plasma etching, film stress, stiction: theory and counter measur Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SUB, rapid prototyping)</li> <li>Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermop modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemomet mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sens piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rasensor: operating principle and fabrication process; spinning current Hall sensor and magneto-transistor; magnetoresist sensors: (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresist sensors: magneto resistance, AMR and GMR, fluxgate magnetometer)</li> <li>Chemical and Bio Sensors (thermal gas sensors; pellistor and thermal conductivity sensor; metal oxide semiconductor quesensor, organic semiconductor gas sensor; bellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor; bellistor, includ</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	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	

ol Systems Theory and Desig	n		
n (L0656)	Typ Lecture	Hrs/wk	<b>CP</b> 4 2
	Recitation Section (Smar	1) 2	2
Introduction to Control Systems			
After taking part successfully, students ha	ve reached the following learning results		
response to initial states or externa  They can explain the system prope estimation, respectively  They can explain the significance of they can explain observer-based storm are they can explain observer-based storm are they can explain the z-transform are they can explain state space model they can explain the experimental is be solved by solving a normal equal they can explain how a state space  Students can transform transfer function of they can design LQG controllers for they can carry out a controller design a given sampling rate  They can identify transfer function of	l excitation as trajectories in state space rties controllability and observability, and the rties controllability and observability, and the aminimal realisation ate feedback and how it can be used to achie multi-input multi-output systems and its relationship with the Laplace Transform is and transfer function models of discrete-time dentification of ARX models of dynamic systetion model can be constructed from a discrete-time ction models into state space models and viccobservability and construct minimal realisation multivariable plants sign both in continuous-time and discrete-time models and state space models of dynamic systems.	eir relationship to sta we tracking and distur- ne systems ms, and how the ider ne impulse response e versa ns e domain, and decide stems from experime	te feedback and state bance rejection  tification problem car  which is appropriate
		imentation experime	ent quides) and use i
when solving given problems.	,, dece	, oxportine	J 22, 2.14 436 1
They can assess their knowledge in weekly	on-line tests and thereby control their learni	na progress	
They can assess then knowledge in treeking			
Independent Study Time 124 Study Time	in Lecture 56		
6			
None			
Written exam			
120 min			
Computational Science and Engineering: S International Management and Engineerin International Management and Engineerin Mechanical Engineering and Management: Mechatronics: Core Qualification: Compuls Biomedical Engineering: Specialisation Art Biomedical Engineering: Specialisation Imp Biomedical Engineering: Specialisation Me Biomedical Engineering: Specialisation Ma	pecialisation II. Engineering Science: Elective g: Specialisation II. Electrical Engineering: Eleg: Specialisation II. Mechatronics: Elective Corspecialisation Mechatronics: Elective Compuory ificial Organs and Regenerative Medicine: Electloants and Endoprostheses: Elective Compuls dical Technology and Control Theory: Compulnagement and Business Administration: Elective	ctive Compulsory inpulsory lsory ctive Compulsory ory sory ive Compulsory	
	Prof. Herbert Werner None Introduction to Control Systems  After taking part successfully, students have a students can explain how linear dynamics are supposed to initial states or externation. They can explain the system properestimation, respectively They can explain the significance of they can explain observer-based stomation, respectively They can explain observer-based stomation, respectively They can explain observer-based stomation the system properestimation of the above to they can explain the zetransform are they can explain the zetransform are they can explain the experimental in the solved by solving a normal equal to they can explain how a state space of they can explain how a state space of they can explain how a state space of they can carry out a controller design and they can carry out a controller design and they can carry out all these tasks simulink)  Students can work in small groups on specific takes to the simulation of the solving given problems.  They can assess their knowledge in weekly independent Study Time 124, Study Time 6  None Written exam  120 min  Electrical Engineering: Core Qualification: Electival Engineering: Core Qualification: Computational Management and Engineering: Specialisation and Engineering and Management and Engineering Mechanical Engineering and Management and Engineering Mechanical Engineering: Specialisation Art Biomedical Engineering: Specialisation Mesiomedical Engineering: Specialisation Mesi	(L0656) Lecture Recitation Section (smal) Prof. Herbert Werner None Introduction to Control Systems  After taking part successfully, students have reached the following learning results  • Students can explain how linear dynamic systems are represented as state spiresponse to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and the estimation, respectively • They can explain the significance of a minimal realisation • They can explain the stempton and its relationship with the Laplace Transform • They can explain the z-transform and its relationship with the Laplace Transform • They can explain the z-transform and its relationship with the Laplace Transform • They can explain the experimental identification of ARX models of dynamic syste be solved by solving a normal equation • They can explain how a state space model and transfer function models of discrete-tim • Students can transform transfer function models into state space models and vice • They can assess controllability and observability and construct minimal realisatio • They can design LOG controllers for multivariable plants • They can carry out a controller design both in continuous-time and discrete-tim for a given sampling rate • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models and state space models of dynamic sy • They can identify transfer function models in formation from provided sources (lecture notes, software documents)  Students can obtain information from provided sou	Typ Hrs/wk Lecture 2 Prof. Herbert Wemer None Introduction to Control Systems  After taking part successfully, students have reached the following learning results

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

Course L0657: Control Syste	ourse 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	

Courses				
itle		Тур	Hrs/wk	CP
he Digital Enterprise (L0932)	2020)	Lecture	2	2
roduction Planning and Control (L roduction Planning and Control (L		Lecture Recitation Section (small)	2 1	2 1
xercise: The Digital Enterprise (L0		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	-			
•	Fundamentals of Production and Qualit	ty Management		
Knowledge				
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of th	he module in detail and take a critical position to them.		
Skills	Skills Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	tence Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	•			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engine	ering: Specialisation II. Product Development and Produ	uction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: S	Specialisation Production and Logistics: Elective Compu	Isory	
	Biomedical Engineering: Specialisation	Artificial Organs and Regenerative Medicine: Elective 0	Compulsory	
	Biomedical Engineering: Specialisation	Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation	Management and Business Administration: Compulsor	у	
	Product Development, Materials and Pr	roduction: Specialisation Product Development: Elective	e Compulsory	
	Product Development, Materials and Pr	roduction: Specialisation Production: Compulsory		
	Product Development, Materials and Pr	roduction: Specialisation Materials: Elective Compulsory	/	
	Theoretical Mechanical Engineering: Sp	pecialisation Product Development and Production: Elec	tive Compulsory	

Course L0932: The Digital Er	nterprise
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	Models of Production and Inventory Management     Production Programme Planning and Lot Sizing     Order and Capacity Scheduling     Selected Strategies of PPC     Manufacturing Control     Production Controlling     Supply Chain Management	
Literature	<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	Recitation Section (small)	
Hrs/wk	1	
СР	1	
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14	
Lecturer	Dr. Axel Friedewald	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses					
Title			Тур	Hrs/wk	CP
Electronic Circuits for Medical Applications (L0696)			Lecture	2	3
Electronic Circuits for Medical Appl			Recitation Section (small)	1	2
	dical Applications (L1408) Practical Course 1 1				
Module Responsible	†				
Admission Requirements	†				
		Fundamentals of electrical engineering			
Knowledge	†				
Educational Objectives		ccessfully, students have rea	sched the following learning results		
Professional Competence Knowledge	Students car     Students are     Students car     Students car     Students car     Students car	able to explain the build-up exemplify the communicati describe the special feature explain the functions of pro	ity of the information transfer by the cent of an action potential and its propagation on between neurons and electronic device is of low-noise amplifiers for medical appl stheses, e. g. an artificial hand and limitations of cochlea implants and a	along an axon es ications	
Skills	<ul><li>Students car</li><li>Students car</li><li>Students ca</li></ul>	give scenarios for further in develop the block diagram	ent voltage behavior of an action potentian provement of low-noise and low-power sof prosthetic systemsof electronic systemsof an articifial eye.		
Personal Competence Social Competence					
Autonomy	<ul> <li>Students are able to realistically judge the status of their knowledge and to define actions for improvements wh necessary.</li> <li>Students can break down their work in appropriate work packages and schedule their work in a realistic way.</li> <li>Students can handle the complex data structures of bioelectrical experiments without needing support.</li> <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 Led	ture 56		
Credit points					
Course achievement	Yes None  No None	Form Subject theoretical practical work Excercises	<b>Description</b> and		
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	Electrical Engineeri	ng: Specialisation Medical Te	chnology: Elective Compulsory		
Following Curricula	Biomedical Engine	ring: Specialisation Artificial	Organs and Regenerative Medicine: Elect	ive Compulsory	
	Biomedical Engine	ring: Specialisation Implants	and Endoprostheses: Elective Compulsor	у	
	Biomedical Enginee	ring: Specialisation Medical	Technology and Control Theory: Compulso	ory	
	Biomedical Enginee	ring: Specialisation Manager	nent and Business Administration: Electiv	e Compulsory	
	Microelectronics an	d Microsystems: Specialisati	on Microelectronics Complements: Electiv	e Compulsory	
	1		on Bio- and Medical Technology: Elective		

Course L0696: Electronic Circ	cuits 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/

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

Course L1408: Electronic Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<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/

Module M1150: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g.,	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-		
Knowledge	body principle, linear-elastic constitutive laws, strain en	ergy).		
Educational Objectives	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to	calculate the mechanical behavior of r	naterials.	
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			pplied contexts as in
Personal Competence				
Social Competence	The students are able to develop solutions, to present t	hem to specialists in written form and	to develop ideas	further.
Autonomy	The students are able to assess their own strengths an problems in the area of continuum mechanics and acqu	· ·	•	wn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Cor	npulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation	n Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective	ve Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	•	Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol		-	
	Biomedical Engineering: Specialisation Management an		mpulsory	
	Product Development, Materials and Production: Core C			
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

Course L1533: Continuum Me	echanics
Тур	Lecture
Hrs/wk	2
	3
	Prof. Christian Cyron
Language	
Cycle	Wi5e
Content	Fundamentals of tensor calculus
	Transformation invariance
	Tensor algebra
	Tensor analysis
	Kinematics
	Motion of continuum
	<ul> <li>Deformation of infinitesimal line, area and volume elements</li> </ul>
	Material and spatial description
	Polar decomposition
	Spectral decomposition
	Objectivity
	Strain measures
	Time derivatives
	Partial / material time derivatives
	<ul> <li>Objective time rates</li> </ul>
	<ul> <li>Strain and deformation rates</li> </ul>
	Transport theorems
	Balance equations (global and local form)
	Balance of mass
	The stress state
	■ Surface traction vectors
	■ Cauchy's fundamental theorem
	<ul><li>Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)</li></ul>
	Balance of linear momentum
	Balance of angular momentum
	Balance of energy
	Balance of entropy
	Clausius-Duhem inequality
	Constitutive laws
	Constitutive assumptions
	• Fluids
	Elastic solids
	Hyperelasticity
	Material symmetry
	Elasto-plastic solids     Applications
	Analysis  A Initial boundary value problems and their numerical colution.
	<ul> <li>Initial-boundary value problems and their numerical solution</li> </ul>
121	D. Carron Manking was an add of Fig. Considering 6th language on 1.01 of 1.00
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer
	weitere siehe in der Literaturliste des Scripts

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		

Module M1151: Mater	rials Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
<b>Recommended Previous</b>	Basics of linear and nonlinear continuum mechanics as tau	ght, e.g., in the modules Mechanic	s II and Continuu	ım Mechanics (forces
Knowledge	and moments, stress, linear and nonlinear strain, free-body	principle, linear and nonlinear cor	stitutive laws, st	rain energy)
<b>Educational Objectives</b>	After taking part successfully, students have reached the fo	ollowing learning results		
<b>Professional Competence</b>				
Knowledge	The students can explain the fundamentals of multidimensi	onal consitutive material laws		
Skills	The students can implement their own material laws in fini	te element codes. In particular, th	e students can a	pply their knowledge
	to various problems of material science and evaluate the co	orresponding material models.		
Personal Competence				
Social Competence	The students are able to develop solutions, to present them	n to specialists and to develop idea	s further.	
Autonomy	The students are able to assess their own strengths and we problems in the area of materials modeling and acquire the	·	y and on their ov	wn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Comput	Isory		
Following Curricula	Mechanical Engineering and Management: Specialisation M	aterials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endop	rostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management and Bu	usiness Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Core Quali	fication: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Material	s Science: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulati	on Technology: Elective Compulso	ry	

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

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

Module M1199: Adva	nced Functional Materials		
Courses			
Title	Typ Hrs/wk CP		
Advanced Functional Materials (L16	Seminar 2 6		
Module Responsible	Prof. Patrick Huber		
Admission Requirements	None		
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particu		
	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 needs and the configurations according to the technical needs and the configurations according to the configuration according to the configurat		
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview		
	modern materials science, which enables them to select optimum materials combinations depending on the techni-		
	applications.		
Personal Competence			
_	The students are able to present solutions to specialists and to develop ideas further.		
·			
Autonomy	The students are able to		
	assess their own strengths and weaknesses.		
	gather new necessary expertise by their own.		
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28		
Credit points			
Course achievement	None		
Examination	Presentation		
Examination duration and	30 min		
scale			
Assignment for the	Materials Science: Core Qualification: Compulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory		

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

Module M1241: Selec	ted Topics of Biomedical Engineering	J - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomecha	anics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	ss (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	indoprostheses: Elective Compulsory		
-	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

Course L1663: Nature's Hiera	archical Materials
	Seminar
Hrs/wk	
CP	
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
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Contain	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well a Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagatic and Electromagnetic Compatibility will be introduced and discussed.  Topics:  - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

Course L1588: Development	and Regulatory Approval of Medical Devices
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<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 L0377: Experimental Methods in Biomechanics		
·		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 min	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	SoSe	
Content		
Literature	Wird in der Veranstaltung bekannt gegeben	

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<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	Klausur	
Examination duration and	90 Minuten	
scale		
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	schriftliche ausarbeitung und Vortrag (20 min)
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Tom	Lactura	
Тур	Lecture	
Hrs/wk	2	
СР	4	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
Examination Form	Klausur	
xamination duration and		
scale		
Lecturer	Prof. Michael Schlüter	
Language	DE	
Cycle	WiSe	
Content		
	Differential equations for momentum-, heat and mass transfer	
	Examples for simplifications of the Navier-Stokes Equations	
	Unsteady momentum transfer	
	Free shear layer, turbulence and free jets     Flavoration of this process Facility Pr	
	Flow around particles - Solids Process Engineering	
	Coupling of momentum and heat transfer - Thermal Process Engineering  Plantage Pinanage Fair and transfer - Thermal Process Engineering	
	Rheology - Bioprocess Engineering  Continue (Continue Continue Continu	
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering	
	Flow threw porous structures - heterogeneous catalysis	
	Pumps and turbines - Energy- and Environmental Process Engineering	
	Wind- and Wave-Turbines - Renewable Energy	
	Introduction into Computational Fluid Dynamics	
Literature	1. Description of the Financian and Mahambaranahii and an Augustian Access Franchisch (AN) 1071	
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.	
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.	
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.	
	<ol> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelber 2006.</li> </ol>	
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.	
	<ol> <li>Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunge Springer Verlag, Berlin, Heidelberg, New York, 2006.</li> </ol>	
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GV	
	Fachverlage GmbH, Wiesbaden, 2008.	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne	
	GWV Fachverlage GmbH, Wiesbaden, 2009.	
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.	
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring	
	Verlag, Berlin, Heidelberg, 2008.	
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.	

Course L1820: System Simul	ation
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.  Instruction and modelling of physical processes Modelling and limits of model Time constant, stiffness, stability, step size Terms of object orientated programming Differential equations of simple systems Introduction into Modelica Introduction into simulation tool Example: Hydraulic systems and heat transfer Example: System with different subsystems
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</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", at- 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 Systems with Modelica", Wiley, New York, 2011.</li> </ul>

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

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

Module M12/9: MED	i. introduction to blochem	nistry and Molecular Biology		
Courses				
Title		Тур	Hrs/wk	СР
Introduction to Biochemistry and M	olecular Biology (L0386)	Lecture	2	3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, student	ts have reached the following learning results		
Professional Competence				
Knowledge	The students can			
	<ul> <li>describe basic biomolecules;</li> </ul>			
	explain how genetic information	n is coded in the DNA;		
	<ul> <li>explain the connection between</li> </ul>			
Skills	The students can			
	recognize the importance of mo	olecular parameters for the course of a disease;		
	describe selected molecular-dia	agnostic procedures;		
	<ul> <li>explain the relevance of these</li> </ul>	procedures for some diseases		
Barraral Carrartana				
Personal Competence	The short arts are marking the in discussion		-1	
Social Competence	ine students can participate in discus	ssions in research and medicine on a technical leve	21.	
Autonomy	The students can develop understand	ling of topics from the course, using technical litera	ature, by themselves.	
Workload in Hours	Independent Study Time 62, Study Time	me in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German	n program, 7 semester): Specialisation Biomedical	Engineering: Compulsory	
Following Curricula	General Engineering Science (Germ	nan program, 7 semester): Specialisation Mech	nanical Engineering, Focu	us Biomechanics
	Compulsory			
	Data Science: Specialisation Medicine	:: Compulsory		
	Electrical Engineering: Specialisation I	Medical Technology: Elective Compulsory		
	Engineering Science: Specialisation Bi	iomedical Engineering: Compulsory		
	General Engineering Science (English	program, 7 semester): Specialisation Biomedical E	Engineering: Compulsory	
	General Engineering Science (Engli	ish program, 7 semester): Specialisation Mech	nanical Engineering, Focu	us Biomechanics
	Compulsory			
	Mechanical Engineering: Specialisation	n Biomechanics: Compulsory		
	Biomedical Engineering: Specialisation	n Management and Business Administration: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation	n Artificial Organs and Regenerative Medicine: Elec	ctive Compulsory	
	Biomedical Engineering: Specialisation	n Medical Technology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation	n Implants and Endoprostheses: Elective Compulso	ory	
	Technomathematics: Specialisation III	I. Engineering Science: Elective Compulsory		

Course I 0386: Introduction t	to Biochemistry and Molecular Biology
	Lecture Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008

Module M1334: BIO II	: Biomaterials
Courses	
Title	Typ Hrs/wk CP
Biomaterials (L0593)	Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is recommended.
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields o 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	90 min
scale	
Assignment for the	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory
Following Curricula	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: Specialisation Bio- and Medical Technology: Elective Compulsory

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

Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials)	and Mechanics II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential	equations)		
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowled overview of the theoretical and methodical by	ge regarding the derivation of the finite eleme	ent method and	are able to give
Skills	The students are capable to handle engined system matrices, and solving the resulting s	ering problems by formulating suitable finite elements of equations.	ments, assemblir	ng the correspondi
Personal Competence Social Competence	Students can work in small groups on specifi	c problems to arrive at joint solutions.		
Autonomy	The students are able to independently so Problems can be identified and the results as	olve challenging computational problems and cre critically scrutinized.	develop own fini	te element routino
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement		Description		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Compu	Isory		
Following Curricula	Energy Systems: Core Qualification: Elective	Compulsory		
	Aircraft Systems Engineering: Specialisation	Aircraft Systems: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation	Air Transportation Systems: Elective Compulsory		
	Aircraft Systems Engineering: Core Qualifica	tion: Elective Compulsory		
	International Management and Engineering:	Specialisation II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering:	Specialisation II. Product Development and Produ	uction: Elective C	ompulsory
	Mechatronics: Core Qualification: Compulsor			•
	Biomedical Engineering: Specialisation Impla			
		gement and Business Administration: Elective Co	mpulsory	
		cal Technology and Control Theory: Elective Com		
		cial Organs and Regenerative Medicine: Elective (		
	Product Development, Materials and Product	y y		
	Technomathematics: Specialisation III. Engin			
	T recimoniathematics; specialisation in From	eering Science: Elective Compulsorv		

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

Course L0804: Finite Elemen	ourse L0804: Finite Element Methods		
Тур	Recitation Section (large)		
Hrs/wk			
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: Polyn				
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polyme		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements				
	Basics: chemistry / physics / material se	cience		
Knowledge				
Educational Objectives		have reached the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plas	stics and define the necessary testing and analys	ils.	
	They can explain the complex relations	ships structure-property relationship and		
	the interactions of chemical structure of	of the polymers, including to explain neighboring	contexts (e.g. sustaina	hility environments
	protection).	the polymers, including to explain heighboring	contexts (e.g. sustaina	ibility, environments
	protection).			
Skills	Students are capable of			
	- using standardized calculation met	hods in a given context to mechanical proper	ties (modulus, strena	th) to calculate an
	evaluate the different materials.	3	,, <u>.</u>	,
	- selecting appropriate solutions for me	echanical recycling problems and sizing example	stiffness, corrosion res	sistance.
Personal Competence				
Social Competence	Students can			
	arrive at funded work regults in beter	aganius graups and dagument them		
	- arrive at funded work results in hetero	ogenius groups and document them.		
	- provide appropriate feedback and har	ndle feedback on their own performance construc	tively.	
Autonomy	Students are able to			
	- assess their own strengths and weakr	nesses.		
	- assess their own state of learning in s	specific terms and to define further work steps on	this basis.	
	- assess possible consequences of their	r professional activity.		
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Workload in Hours		me in Lecture 56		
Credit points				
Course achievement				
Examination Examination duration and				
examination duration and scale				
Assignment for the		eering Materials: Flective Compulsory		
Following Curricula	,	Implants and Endoprostheses: Compulsory		
		Artificial Organs and Regenerative Medicine: Elec	ctive Compulsory	
		Management and Business Administration: Elect		
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Elective	Compulsory	
	Product Development, Materials and Pr	oduction: Specialisation Production: Elective Com	npulsory	
	Product Development, Materials and Pr	oduction: Specialisation Materials: Elective Comp	oulsory	
	· ·	oduction: Specialisation Product Development: E		
	Theoretical Mechanical Engineering: Sp	pecialisation Materials Science: Elective Compulso	ory	

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

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

Courses						
Title			Тур	Hrs/wk	СР	
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (I 166		Seminar Seminar	2	3 3	
Module Responsible						
Admission Requirements						
Recommended Previous						
Knowledge	None					
Educational Objectives	After taking part suc	essfully, students have re	ached the following learning results			
Professional Competence	3 1 3 1	,,				
	After successful con	letion of the module stu	dents will be able to describe the basi	ic methods of regenera	tive medicine and	
			methods of tissue engineering. They are			
	the cultivation of ani	al and human cells.				
	The students can	tling the actual concor	ts of Tissue Engineering and regener	rative medicine and ca	n ovalain the bac	
		of the discussed topics.	is of fissue Engineering and regener	ative medicine and ca	iii explaiii tile bas	
	adirectlying principles	or the diseassed topies.				
Skills	After successful com	letion of the module stud	ents are			
	able to use m	lical databases for acquir	ierung and presentation of relevant up-	to-date data independe	ntlv	
		their work results in the			,	
	able to carry of	t basic cell culture metho	ods and the corresponding analysis inde	pendently		
	able to analys	and evaluate current res	earch topics for Tissue Engineering and	regenerative medicine.		
Personal Competence						
Social Competence	Students are able to	ork together as a team i	with 2-4 students to solve given tasks a	nd discuss their results	in the plenary and	
Social competence	defend them.	Tork together as a team of	with 2-4 students to solve given tusks u	na aiscuss tricii results	in the pichary and	
	derend arenn					
	Students are able to	eflect their work orally ar	d discuss it with other students and tea	ichers.		
Autonomy						
	After completion of	this module, participant	s will be able to solve a technical	problem in teams of a	approx. 2-4 perso	
	independently includ	independently including a presentation of the results.				
Maddend in Herre	Ladanandant Chidu 7	124 Charle Time in Le				
Workload in Hours		ne 124, Study Time in Le	cture 56			
Credit points  Course achievement		Form	Description			
Course achievement	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pr	otocol for lecture series		
Examination	Presentation		3 3 3 1			
Examination duration and	Oral presentation +	scussion (30 min)				
scale		,				
Assignment for the	Biomedical Engineer	g: Specialisation Implant	s and Endoprostheses: Elective Compul	sory		
Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory					
-	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
	Biomedical Engineer	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				

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

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			

Module M1333: BIO I:	Implants and Fracture Healing
Courses	
Title	Typ Hrs/wk CP
Implants and Fracture Healing (L03	2 3 Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".
Knowledge	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.
GL !!!	
SKIIIS	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
Personal Competence	
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	90 min
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha
Following Curricula	Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	Engineering Science: Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomecha
	Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	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 Compulsory
	Orientation Studies: Core Qualification: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0376: Implants and	Fracture Healing
Тур	Lecture
Hrs/wk	
CP	
	Independent Study Time 62, Study Time in Lecture 28 Prof. Michael Morlock
Language	
Cycle	
Content	Topics to be covered include:
	Introduction (history, definitions, background importance)
	2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)
	3.1 The spine in its entirety
	3.2 Cervical spine
	3.3 Thoracic spine
	3.4 Lumbar spine
	3.5 Injuries and diseases
	4. Pelvis (anatomy, biomechanics, fracture treatment)
	5 Fracture Healing
	5.1 Basics and biology of fracture repair
	5.2 Clinical principals and terminology of fracture treatment
	5.3 Biomechanics of fracture treatment
	5.3.1 Screws
	5.3.2 Plates
	5.3.3 Nails
	5.3.4 External fixation devices
	5.3.5 Spine implants
	6.0 New Implants
1 thank	Cockron V.D., Orthon ädische Diemechanik
Literature	Cochran V.B.: Orthopädische Biomechanik
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Module M0630: Robot	tics and Naviga	ntion in Medi	cine			
Courses						
Title  Robotics and Navigation in Medicine (L0335)  Robotics and Navigation in Medicine (L0338)  Robotics and Navigation in Medicine (L0336)			Typ Lecture Project Seminar Recitation Section (small)	<b>Hrs/wk</b> 2 2 1	CP 3 2	
Module Responsible	Prof. Alexander Schla	nefer				
Admission Requirements						
Recommended Previous Knowledge		nath (algebra, anal rogramming, e.g., ab skills				
Educational Objectives	After taking part succ	cessfully, students	have reached the fo	lowing learning results		
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.  The students are able to design and evaluate navigation systems and robotic systems for medical applications.					
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.  The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Study T	ime 110, Study Tin	ne in Lecture 70			
Credit points	6	-				
Course achievement	Compulsory Bonus Yes 10 % Yes 10 %	Form Presentation Written elaborat	<b>D</b> escriptio	n		
Examination	Written exam					
Examination duration and	90 minutes					
scale Assignment for the				g: Elective Compulsory		
Following Curricula	International Manage Mechatronics: Specia Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Biomedical Engineeri Product Developmen	ement and Enginee ement and Enginee disation Intelligent ng: Specialisation ng: Specialisation ng: Specialisation ng: Specialisation t, Materials and Pro	ring: Specialisation I ring: Specialisation I Systems and Robotion Artificial Organs and Implants and Endopr Medical Technology Management and Bu oduction: Specialisat	lective Compulsory  I. Electrical Engineering: Electi I. Process Engineering and Bio I. Elective Compulsory  Regenerative Medicine: Electi I ostheses: Elective Compulsory  I and Control Theory: Elective Compulsory  I on Product Development: Elective I on Production: Elective Comp	ve Compulsory  y  compulsory  e Compulsory  ctive Compulsory	· Compulsory
	Product Developmen	t, Materials and Pro	oduction: Specialisat	ion Materials: Elective Compul Medical Technology: Elective	Isory	

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

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

Course L0336: Robotics and 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	

Module M1384: Case	Studies for Regenerative Med	icine and Tissue Engineering		
Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	icine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have	e reached the following learning results		
<b>Professional Competence</b>				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: Com	pulsory	
Following Curricula	Biomedical Engineering: Specialisation Impla	' '	,	
		agement and Business Administration: Electiv		
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective	Compulsory	

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

Module M0634: Introd	duction into Me	dical Technology a	and Systems		
Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical Technolog	gy and Systems (L0342)		Lecture	2	3
Introduction into Medical Technolog	gy and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technolog	gy and Systems (L1876)		Recitation Section	n (large) 1	1
Module Responsible	Prof. Alexander Schla	efer			
Admission Requirements	None				
Recommended Previous	principles of math (al	gebra, analysis/calculus)			
Knowledge	principles of stochast	tics			
	principles of program	ming, R/Matlab			
Educational Objectives	After taking part succ	essfully, students have rea	thed the following learning resul	lts	
Professional Competence	31		<u> </u>		
Knowledge	The students can ex	plain principles of medica	technology, including imaging	systems, computer aide	d surgery, and medical
	information systems.	They are able to give an ov	erview of regulatory affairs and	standards in medical tech	nology.
Skills	The students are able	to evaluate systems and n	nedical devices in the context of	clinical applications.	
Personal Competence					
Social Competence	The students describe	e a problem in medical tech	nology as a project, and define t	asks that are solved in a j	oint effort.
A 1	Th	and the state of the state of the	and the second section of the factors		
Autonomy					
	manner.				
Workload in Hours	Independent Study Ti	me 110, Study Time in Lect	ure 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
=	Yes 10 %	Presentation			
Examination					
Examination duration and scale	90 minutes				
Assignment for the	General Engineering	Science (German program	7 semester): Specialisation Bion	andical Engineering: Comp	ulsony
Following Curricula	3 3		Software Engineering: Elective (		uisory
			and Engineering Science: Elect		
		ualification: Elective Compu		, , ,	
	Electrical Engineering	: Core Qualification: Electiv	e Compulsory		
	Engineering Science:	Specialisation Biomedical E	ngineering: Compulsory		
	General Engineering S	Science (English program, 7	semester): Specialisation Biome	edical Engineering: Compu	ılsory
	Computational Science	e and Engineering: Special	sation II. Mathematics & Engine	ering Science: Elective Co	mpulsory
	Biomedical Engineering	ng: Specialisation Artificial (	Organs and Regenerative Medici	ne: Elective Compulsory	
	_		and Endoprostheses: Elective Co		
	_		echnology and Control Theory: E		
	_		ent and Business Administration		
	rechnomathematics:	Specialisation III. Engineeri	ng Science: Elective Compulsory	•	

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	2 Engineering Meenanies			
<b>Educational Objectives</b>	After taking part successfully, students have reached t	he following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able to reflect existing terms and conc	epts in Nonlinear Dynamics and to	develop and resea	arch new terms and
	concepts.			
Skills	Students are able to apply existing methods and proce	sures of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks inc	lividually and to identify and follow u	up novel research ta	sks by themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Election	ve Compulsory		
Following Curricula	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	on Mechatronics: Elective Compulsor	ry	
	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and R	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	•	e Compulsory	
	Biomedical Engineering: Specialisation Implants and Er			
	Biomedical Engineering: Specialisation Medical Techno	•		
	Biomedical Engineering: Specialisation Management an		Compulsory	
	Product Development, Materials and Production: Core			
	Theoretical Mechanical Engineering: Core Qualification	: Elective Compulsory		

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.	

nireoe				
ourses				
tle		<b>Typ</b> Lecture	Hrs/wk 4	<b>CP</b> 4
miconductor Technology (L0722 miconductor Technology (L0723		Practical Course	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous		nce and semiconductor devices		
Knowledge	busies in physics, chemistry, material sele	nee and semiconductor devices		
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence	The taking pare succession, forducines in	versualised and renorming searming security		
Knowledge				
ranomeage				
	Students are able			
	to describe and to explain current fab.	rication techniques for Si and GaAs substrates,		
		t fabrication processes, process flows and t	he impact thereof o	n the fabrication
	semiconductor devices and integrated circ	cuits and		
	to present integrated process flows.			
Skills				
	Shadaaha aya sayabla			
	Students are capable			
	to analyze the impact of process para	meters on the processing results,		
	to select and to evaluate processes ar	ad		
	to select and to evaluate processes an	id		
	to develop process flows for the fabric	cation of semiconductor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform	their lab experiments in team work as well as	to present and discus	ss the results in fr
	of audience.	and experiments in team from as from as	to present and albeat	os ene results in in
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study Time in	n Lecture 84		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and				
scale				
Assignment for the		pelectronics and Microsystems Technology: Electronics		
Following Curricula		ificial Organs and Regenerative Medicine: Elect		
		plants and Endoprostheses: Elective Compulson dical Technology and Control Theory: Elective		
	3 3 1	nagement and Business Administration: Elective	. ,	

Lecture
4
4
Independent Study Time 64, Study Time in Lecture 56
Prof. Hoc Khiem Trieu DE/EN
SoSe
<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, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damagannealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetic influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs)</li> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetic temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques</li> </ul>
<ul> <li>APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuur evaporation, sputtering)</li> <li>Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximit and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique an electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electro beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic an anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> <li>Process integration (CMOS process, bipolar process)</li> <li>Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact wire bonding, TAB and flip chip, wafer level package, 3D stacking)</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

Course 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

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
<b>Recommended Previous</b>				
Knowledge	<ul> <li>Introduction to control systems</li> </ul>			
	Control theory and design			
<b>Educational Objectives</b>	After taking part successfully, students have rea	sched the following learning results		
<b>Professional Competence</b>				
Knowledge	<ul> <li>Students can explain humanoid robots.</li> </ul>			
	Students learn to apply basic control cond	cepts for different tasks in humanoid re	obotics.	
	11.7	•		
Skills	<ul> <li>Students acquire knowledge about select</li> </ul>	ed aspects of humanoid robotics, base	ed on specified literature	
	Students generalize developed results an	d present them to the participants		
	<ul> <li>Students practice to prepare and give a p</li> </ul>	resentation		
Darranal Compatons				
Personal Competence Social Competence				
30ciai Competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	<ul> <li>They are able to provide appropriate feed</li> </ul>	lback and handle constructive criticisn	n of their own results	
Autonomy				
Autonomy	<ul> <li>Students evaluate advantages and draw</li> </ul>	vbacks of different forms of present	ation for specific tasks	and select the best
	solution			
	Students familiarize themselves with a state of the		and follow presentation	ns of other students
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lect	ure 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Ele	• •		
	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Implants	·	•	
	Biomedical Engineering: Specialisation Medical	•		
	Biomedical Engineering: Specialisation Manager			
	Theoretical Mechanical Engineering: Specialisati	on Robotics and Computer Science: El	ective Compulsory	

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

Module M0838: Linea	r and Nonlinear System Id	entifikation	
Courses			
Title		Тур	Hrs/wk CP
Linear and Nonlinear System Identi	ification (L0660)	Lecture	2 3
Module Responsible	Prof. Herbert Werner		
Admission Requirements	None		
Recommended Previous			
Knowledge	<ul> <li>Classical control (frequency res</li> <li>State space methods</li> </ul>	porise, root locus)	
	Discrete-time systems		
	Linear algebra, singular value d	ecomposition	
	Basic knowledge about stochas		
Educational Objectives	Aπer taking part successfully, student	s have reached the following learning results	5
Professional Competence  Knowledge			
Knowieuge	<ul> <li>Students can explain the gene</li> </ul>	ral framework of the prediction error method	od and its application to a variety of linear and
	nonlinear model structures		
		er perceptron networks are used to model no	
		ximate predictive control scheme can be bas	
	They can explain the idea of sull	bspace identification and its relation to Kalm	an realisation theory
Skills	St. dayle and a state of a state		
	models for dynamic systems	ing the prediction error method to the exp	perimental identification of linear and nonlinear
		ing a nonlinear predictive control scheme ba	sed on a neural network model
			tification of linear models for dynamic systems
		andard software tools (including the Matlab S	
Personal Competence			
Social Competence	Students can work in mixed groups on	specific problems to arrive at joint solutions	
Autonomy	Students are able to find required info	ormation in sources provided (lecture notes,	literature, software documentation) and use it to
,	solve given problems.		
Workload in Hours	Independent Study Time 62, Study Time	ne in Lecture 28	
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and	30 min		
scale			
_		Control and Power Systems Engineering: Elec	
Following Curricula	· · · · · · · · · · · · · · · · · · ·	t Systems and Robotics: Elective Compulsor	y
	Mechatronics: Specialisation System D		- Flactive Communication
		n Artificial Organs and Regenerative Medicine	• •
		n Implants and Endoprostheses: Elective Com n Medical Technology and Control Theory: Co	
		n Management and Business Administration:	
		Findingement and Business Administration.  Fore Qualification: Elective Compulsory	

Course L0660: Linear and No	nlinear System Identification
	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 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					
litle .		Тур	Hrs/wk	СР	
Optimal and Robust Control (L0658	3)	Lecture	2	3	
Optimal and Robust Control (L0659		Recitation Section (small)	2	3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Classical control (frequency response, re	oot locus)			
Knowledge	State space methods				
	<ul> <li>Linear algebra, singular value decompos</li> </ul>	sition			
Educational Objectives	After taking part successfully, students have re	sached the following learning results			
Professional Competence	Arter taking part successfully, students have re	defice the following fearning results			
Knowledge					
		the matrix Riccati equation for the solution of			
		otimal state feedback and optimal state estima			
	· ·	ity norms are used to represent stability and poblem can be formulated as special case of an			
		y can be represented in a way that lends itself			
		nall gain theorem - a robust controller can gu			
	an uncertain plant.				
	<ul> <li>They understand how analysis and synth</li> </ul>	nesis conditions on feedback loops can be repr	esented as linear	matrix inequalities	
Skills					
SKIIIS	<ul> <li>Students are capable of designing and to</li> </ul>	uning LQG controllers for multivariable plant m	nodels.		
		r H-infinity design problem in the form of a ge	neralized plant, a	nd of using standa	
	software tools for solving it.				
		d frequency domain specifications for control	loops into consti	raints on closed-lo	
	sensitivity functions, and of carrying out a mixed-sensitivity design.  They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective.				
	robust controller.				
		s and synthesis conditions as linear matrix inc	equalities (LMI), a	nd of using standa	
	LMI-solvers for solving them.				
	<ul> <li>They can carry out all of the above using</li> </ul>	g standard software tools (Matlab robust contr	ol toolbox).		
Personal Competence					
•	Students can work in small groups on specific p	problems to arrive at joint solutions			
Autonomy	Students are able to find required information		software docume	ntation) and use it	
	solve given problems.	, , , , , , , , , , , , , , , , , , , ,			
Workload in Hours	Independent Study Time 124, Study Time in Le	cture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
<b>Examination duration and</b>	30 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Control a	nd Power Systems Engineering: Elective Comp	ulsory		
Following Curricula	Energy Systems: Core Qualification: Elective Co		,		
	Aircraft Systems Engineering: Core Qualificatio	n: Elective Compulsory			
	Mechatronics: Specialisation Intelligent System	s and Robotics: Elective Compulsory			
	Mechatronics: Specialisation System Design: El	ective Compulsory			
	Biomedical Engineering: Specialisation Artificia	•	Compulsory		
	Biomedical Engineering: Specialisation Implant				
	Biomedical Engineering: Specialisation Medical	**			
	Broduct Development, Materials and Production				
	Product Development, Materials and Production Product Development, Materials and Production				
	Product Development, Materials and Production  Product Development, Materials and Production	·	•		
			,		

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

Module M0855: Marko	eting (Sales and Services / Innovation Ma	arketing)		
Courses				
Title		Тур	Hrs/wk	СР
Marketing of Innovations (L2009)		Lecture	4	4
PBL Marketing of Innovations (L086	52)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous	Module International Business			
Knowledge	Basic understanding of business administration p	rinciples (strategic planning, decisi	on theory, pro	ject management,
	international business)			
	Bachelor-level Marketing Knowledge (Marketing Insti		egies, Basics of	f Buying Behavior)
	Unerstanding the differences beweetn B2B and B2C			
	<ul> <li>Understanding of the importance of managing innov</li> <li>Good English proficiency; presentation skills</li> </ul>	ation in global industrial markets		
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innovativ	e poroducts and services		
	Approaches for analyzing the current market situation	n and the future market developmen	t	
	The gathering of information about future customer			
	Concepts and approaches to integrate lead users and     Approaches and tools for appring systemory orientals.			
	<ul> <li>Approaches and tools for ensuring customer-oriental</li> <li>Marketing mix elements that take into consideratio</li> </ul>			
	services	and specime requirements and end	enges or miles	active produces and
	Pricing methods for new products and services			
	The organization of complex sales forces and person	al selling		
	Communication concepts and instruments for new p	roducts and services		
Skills	Based on the acquired knowledge students will be able to:			
	Design and to evaluate decisions regarding marketing	g and innovation strategies		
	<ul> <li>Analyze markets by applying market and technology</li> </ul>	portfolios		
	Conduct forecasts and develop compelling scenarios			
	Translate customer needs into concepts, prototypes		fully apply adv	anced methods for
	<ul> <li>customer-oriented product and service development</li> <li>Use adequate methods to foster efficient diffusion of</li> </ul>			
	Choose suitable pricing strategies and communication			
	Make strategic sales decisions for products and serv			
	Apply methods of sales force management (i.e. customates)	omer value analysis)		
Personal Competence				
· ·	The students will be able to			
,				
	have fruitful discussions and exchange arguments     develop original results in a group			
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
	A source les souls des in des souls able in the source of the		h 1	
	<ul> <li>Acquire knowledge independently in the specific con</li> <li>Consider proposed business actions in the field of management</li> </ul>		ner new comple	ex problem fields.
	Consider proposed business decions in the neid of the	arketing and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement				
	Subject theoretical and practical work	L!		
Examination duration and scale	Written elaboration, excercises, presentation, oral participa	tion		
Assignment for the	Global Technology and Innovation Management & Entrepre	neurshin: Core Qualification: Compuls	sorv	
Following Curricula			-	
3	Mechanical Engineering and Management: Specialisation M		. ,	
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endop			
	Biomedical Engineering: Specialisation Medical Technology		sory	
	Biomedical Engineering: Specialisation Management and Bi	usiness Administration: Compulsory		

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

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

Module M1143: Appli	ed Design Methodology in Me	echatronics			
Courses					
Title		Ty	ур	Hrs/wk	СР
Applied Design Methodology in Med	chatronics (L1523)	Le	ecture	2	2
Applied Design Methodology in Med	chatronics (L1524)	Pr	roject-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern				
Admission Requirements	None				
Recommended Previous	Basics of mechanical design, electrical desi	ign or computer-sciences	5		
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have	ve reached the following	learning results		
Professional Competence					
Knowledge	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques				
Skills	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of			lems / Application of	
	various product design techniques following	various product design techniques following theoretical aspects.			
Personal Competence					
Social Competence	Students will solve and execute technical	l-scientific tasks from a	n industrial context in small	design-teams	with application of
	common, creative methodologies.				
Autonomy	Students are enabled to optimize the desig	gn and development proc	ess according to the target ar	nd topic of the	design
Workload in Hours	Independent Study Time 110, Study Time i	in Lecture 70			
Credit points	6				
Course achievement	None				
Examination	Subject theoretical and practical work				
Examination duration and	30 min Presentation for a group design-wor	rk			
scale					
Assignment for the	International Management and Engineering	g: Specialisation II. Produ	ct Development and Production	on: Elective Co	ompulsory
Following Curricula	International Management and Engineering	g: Specialisation II. Mecha	atronics: Elective Compulsory		
	Mechanical Engineering and Management:	Specialisation Product D	evelopment and Production: E	Elective Comp	ulsory
	Mechatronics: Specialisation System Design	n: Elective Compulsory			
	Biomedical Engineering: Specialisation Arti	ificial Organs and Regene	erative Medicine: Elective Com	npulsory	
	Biomedical Engineering: Specialisation Imp	plants and Endoprosthese	es: Elective Compulsory		
	Biomedical Engineering: Specialisation Med	dical Technology and Cor	ntrol Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Mar	nagement and Business A	Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specia	alisation Product Develop	ment and Production: Elective	e Compulsory	

Course L1523: Applied Desig	n Methodology in Mechatronics
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul> <li>Systematic analysis and planning of the design process for products combining a multitude of disciplines</li> <li>Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation)</li> <li>Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, Applications in examples all around mechatronics topics)</li> <li>Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing,)</li> <li>Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making</li> <li>Value-analysis</li> <li>Derivation of architectures and architectural management</li> <li>Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&amp;D departments, idea-identification, responsibilities and communication)</li> <li>Project-execution methods (Scrum, Kanbaan,)</li> <li>Presentation-skills</li> <li>Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces)</li> <li>Evaluation of selected methods at practical examples in small teams</li> </ul>
	<ul> <li>Definition folgt</li> <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: Applied Desig	ourse L1524: Applied Design Methodology in Mechatronics		
Тур	Project-/problem-based Learning		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Thorsten Kern		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses					
Title	(100.00)	Тур	Hrs/wk	СР	
Bioprocess Engineering - Fundame Bioprocess Engineering- Fundamer		Lecture Recitation Section (large	2 e) 2	3 1	
Bioprocess Engineering - Fundame		Practical Course	2	2	
Module Responsible					
Admission Requirements					
	none, module "organic chemistry", module "	fundamentals for process engineering"			
Knowledge	,	, , , , , , , , , , , , , , , , , , ,			
Educational Objectives	After taking part successfully, students have	reached the following learning results			
<b>Professional Competence</b>					
Knowledge	Students are able to describe the basic cond	cepts of bioprocess engineering. They are a	ble to classify differen	it types of kinetics	
	enzymes and microorganisms, as well as	to differentiate different types of inhibit	on. The parameters	of stoichiometry a	
	rheology can be named and mass transpo	ort processes in bioreactors can be expla	ned. The students ar	e capable to expl	
	fundamental bioprocess management, steril	ization technology and downstream proces	sing in detail.		
Skills	After successful completion of this module, s	tudents should be able to			
Skills	Arter successful completion of this module, s	students should be able to			
	describe different kinetic approaches	for growth and substrate-uptake and to cal	culate the correspondi	ng parameters	
	<ul> <li>predict qualitatively the influence of</li> </ul>	energy generation, regeneration of redox	c equivalents and gro	wth inhibition on	
	fermentation process	fermentation process			
	· '	chiometry and to set up / solve metabolic flu	•		
		for different bioreactors and bioprocesses (	anaerobic, aerobic as	well as microaerol	
	to compare them as well as to apply them to current biotechnical problem				
	propose solutions to complicated blot	echnological problems and to deduce the c	orresponding models		
	<ul> <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					
Social Competence					
	take position to their own opinions and incre	ase their capacity for teamwork in enginee	ring and scientific envi	ronments.	
Autonomy	After completion of this module participants	will be able to solve a technical problem i	n a team independent	ly by organizing th	
,	workflow and to present their results in a pl			, , , , , , ,	
	Independent Study Time 96, Study Time in L	ecture 84			
Credit points					
Course achievement	Yes 5 % Subject theoretical	<b>Description</b> and			
	practical work	anu			
Examination	,				
Examination duration and	90 min			<del></del>	
scale	30 11111				
Scale					
Assignment for the	General Engineering Science (German progr	am, 7 semester): Specialisation Process En	gineering: Compulsory		
Following Curricula	General Engineering Science (German progr		Engineering: Compuls	ory	
	Bioprocess Engineering: Core Qualification:				
	Green Technologies: Energy, Water, Climate	,	. ,		
	Biomedical Engineering: Specialisation Artific				
	Biomedical Engineering: Specialisation Impla	·	•		
	Biomedical Engineering: Specialisation Medi				
	Biomedical Engineering: Specialisation Mana	•	ive Compulsory		
	Technomathematics: Specialisation III. Engir				
	Process Engineering: Core Qualification: Con	npulsory			

Course L0841: Bioprocess Engineering - Fundamentals			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese		
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>Technology of sterilization (Prof. Zeng)</li> <li>Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-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	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012  H. Chmiel: Bioprozeßtechnik, Elsevier, 2006  R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010  H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997  P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013		

Course L0842: Bioprocess En	ourse 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				
Language	DE				
Cycle	SoSe				
Content	1. Introduction (Prof. Liese, Prof. Zeng)				
	2. Enzymatic kinetics (Prof. Liese)				
	3. Stoichiometry I + II (Prof. Liese)				
	4. Microbial Kinetics I+II (Prof. Zeng)				
	5. Rheology (Prof. Liese)				
	5. Mass transfer in bioprocess (Prof. Zeng)				
	7. Continuous culture (Chemostat) (Prof. Zeng)				
	8. Sterilisation (Prof. Zeng)				
	9. Downstream processing (Prof. Liese)				
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)				
Literature	siehe Vorlesung				

Course L0843: Bioprocess En	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 M1277: MED I	: Introduction to Anatomy				
Courses					
Title	Typ Hrs/wk CP				
Introduction to Anatomy (L0384)	Lecture 2 3				
Module Responsible	Prof. Udo Schumacher				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system.				
	The students can describe the basic macroscopy and microscopy of those systems.				
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; th				
Skins	can explain the relevance of structures and their functions in the context of widespread diseases.				
Personal Competence					
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.				
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui				
	the relevant knowledge themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points					
Course achievement					
Examination	Written exam				
	90 minutes				
scale					
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic				
	Compulsory				
	Data Science: Specialisation Medicine: Compulsory				
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory				
	Engineering Science: Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory  Technomathematics: Specialisation III. Engineering Science: Elective Compulsory				
	recumomathematics, specialisation in, engineering science, elective compulsory				

avT	Lecture				
Hrs/wk					
СР					
Workload in Hours	Independent Study	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Tobias Lange				
Language	DE				
Cycle					
Content	General Anatomy				
	1 <sup>st</sup> week:	The Eucaryote Cell			
	2 <sup>nd</sup> week:	The Tissues			
	Z*** 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:	ch week: Cardiovascular System			
	6 <sup>th</sup> week:	th week: Respiratory System			
	7 <sup>th</sup> week:	th week: Genito-urinary System			
	8 <sup>th</sup> week:	th week: Immune system			
	9 <sup>th</sup> week:	th week: Digestive System I			
	10 <sup>th</sup> week:	.0 <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/Michael	Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016			

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Courses					
Title		Тур	Hrs/wk	CP	
Introduction to Physiology (L0385)		Lecture	2	3	
Module Responsible	Dr. Roger Zimmermann				
Admission Requirements					
Recommended Previous	None				
Knowledge					
-	After taking part successfully, students have reached	the following learning results			
Professional Competence	The state of the s				
Knowieage	The students can				
	<ul> <li>describe the basics of the energy metabolism;</li> </ul>				
	<ul> <li>describe physiological relations in selected fiel</li> </ul>	ds of muscle, heart/circulation, r	neuro- and sensory physic	ology.	
Skills	The students can describe the effects of basic bodily	functions (sensory transmission	n and processing of inforr	nation developme	
Skins	of forces and vital functions) and relate them to simil		in und processing of inform	nation, acveropine	
Personal Competence					
Social Competence	The students can conduct discussions in research and	d medicine on a technical level.			
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	The students can find solutions to problems in the field of physiology, both analytical and metrological.				
Autonomy	'	ig in the course and other phys	siological areas, using te	chnical literature,	
	themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	8			
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and	60 minutes				
scale					
Assignment for the	General Engineering Science (German program, 7 se	mester): Specialisation Biomedic	al Engineering: Compulso	ory	
Following Curricula	General Engineering Science (German program,	7 semester): Specialisation Me	echanical Engineering, F	ocus Biomechanio	
	Compulsory				
	Data Science: Specialisation Medicine: Compulsory	lagur Flastiva Compulsory			
	Electrical Engineering: Specialisation Medical Techno Engineering Science: Specialisation Biomedical Engin				
	General Engineering Science (English program, 7		echanical Engineering F	ocus Biomechani	
	Compulsory	semester). Specialisation Me	chanical Engineering, 1	ocus biomechani	
	General Engineering Science (English program, 7 sen	nester): Specialisation Biomedica	al Engineering: Compulsor	ry	
	General Engineering Science (English program, 7 sen	•		-	
	Mechanical Engineering: Specialisation Biomechanics	•		•	
	Biomedical Engineering: Specialisation Medical Techr	ology and Control Theory: Electi	ive Compulsory		
	Biomedical Engineering: Specialisation Management	and Business Administration: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation Artificial Orga	ns and Regenerative Medicine: E	Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and	Endoprostheses: Elective Compu	ılsory		

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

Module M1278: MED	l: Introduction to Radiology and Radiation Therapy				
Courses					
Title	Typ Hrs/wk CP				
Introduction to Radiology and Radio					
Module Responsible					
Admission Requirements  Recommended Previous					
Knowledge	Note				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.				
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).				
	The students can describe the patients' passage from their initial admittance through to follow-up care.				
	Diagnostics				
	The students can illustrate the technical base concepts of projection radiography, including 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 treatment method depending on the patient's clinical history and needs.				
	The student can explain the influence of technical errors on the imaging techniques.				
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.				
Skills	Therapy				
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.				
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.				
	The students can use the therapeutic principle (effects vs adverse effects)				
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).				
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).				
	Diagnostics				
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.				
	The students can classify results of imaging techniques according to different groups of diseases based on their knowleanatomy, 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 therapeuti 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					
Examination Examination duration and	Written exam				
examination duration and scale	20 minutes				
Assignment for the Following Curricula					
	Data Science: Specialisation Medicine: Compulsory				
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1335: BIO II	: Artificial Joint Replacement				
Courses					
Title		Тур	Hrs/wk	СР	
Artificial Joint Replacement (L1306)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
<b>Admission Requirements</b>	None				
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is reco	mmended.			
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have reached the follo	wing learning results			
<b>Professional Competence</b>					
Knowledge	The students can name the different kinds of artificial limbs.				
CI-:II-					
SKIIIS	The students can explain the advantages and disadvantages of different kinds of endoprotheses.				
Personal Competence					
Social Competence	The students are able to discuss issues related to endoprothese with student mates and the teachers.				
Autonomic	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.				
Autonomy	The students are able to acquire information on their own. Th	ey can also judge the ii	normation with respect to	its credibility.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	International Management and Engineering: Specialisation II.	Process Engineering an	d Biotechnology: Elective (	Compulsory	
Following Curricula	Materials Science: Specialisation Nano and Hybrid Materials: E	Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs and R	egenerative Medicine: I	Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and Endopros				
	Biomedical Engineering: Specialisation Medical Technology ar	•			
	Biomedical Engineering: Specialisation Management and Busi	ness Administration: Ele	ective Compulsory		
	Orientation Studies: Core Qualification: Elective Compulsory				
	Theoretical Mechanical Engineering: Specialisation Bio- and M	edical Technology: Elec	tive Compulsory		

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

Module M0845: Feedl	oack Control in Medical Techn	nology			
Courses					
Title		Тур	Hrs/wk	СР	
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3	
Module Responsible	Johannes Kreuzer				
Admission Requirements	None				
Recommended Previous	Basics in Control, Basics in Physiology				
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, students have	ve reached the following learning results			
<b>Professional Competence</b>					
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.				
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system to example in for anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will billustrated. 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 res	sults		
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	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Medic	cal Technology: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Contr	rol and Power Systems Engineering: Elective Co	ompulsory		
		plants and Endoprostheses: Elective Compulsor	•		
		ificial Organs and Regenerative Medicine: Elect			
		nagement and Business Administration: Electiv			
	Biomedical Engineering: Specialisation Med	dical Technology and Control Theory: Compuls	ory		

Course L0664: Feedback Con	itrol in Medical Technology		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Lecturer	Johannes Kreuzer, Christian Neuhaus		
Language	DE .		
Cycle	SoSe		
Content	Always viewed from the engineer's point of view, the lecture is structured as follows:		
	<ul> <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> <li>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.</li> </ul>		
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 M0635: Medic	al Technology Lab				
Courses					
Title			Тур	Hrs/wk	СР
Medical Technology Lab (L1096)			Project-/problem-based Learning	6	6
Module Responsible	Prof. Alexander Schlaefer				
Admission Requirements	None				
Recommended Previous	sound programming skills (Java / C+	+)			
Knowledge	skills in R/Matlab				
	knowledge of image processing				
	principles of math (algebra, analysis	/calculus)			
	principles of stochastics				
Educational Objectives	After taking part successfully, stude	nts have reached the followi	ng learning results		
<b>Professional Competence</b>					
Knowledge	The students recognize the complex	kity of medical technology a	nd can explain, which methods a	re appropriate	e to solve a problem
	at hand.				
Skills	The students are able to analyze and	d solve problems in medical	technology.		
Personal Competence					
Social Competence	The students can define project air appropriate manner.	ms and scope and organize	the project as team work. The	y can presen	t their results in an
Autonomy	The students take responsibility for	their tasks and coordinate t	heir individual work with other q	roup members	s. They deliver their
	work on time. They independently a		-	•	
Workload in Hours	ndependent Study Time 96, Study T	Time in Lecture 84			
Credit points	6				
Course achievement	Compulsory Bonus Form Yes None Group discus	<b>Description</b> sion			
Examination	Written elaboration				
Examination duration and	approx. 8 pages, time frame: over th	ne course of the semester			
scale					
Assignment for the	Electrical Engineering: Specialisation	n Medical Technology: Electiv	ve Compulsory		
Following Curricula	Biomedical Engineering: Specialisati	on Medical Technology and	Control Theory: Elective Compuls	ory	

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

Module MU832: Adva	nced Topics in Control
Courses	
Title	Typ Hrs/wk CP
Advanced Topics in Control (L0661	••
Advanced Topics in Control (L0662	Recitation Section (small) 2 3
Module Responsible	Prof. Herbert Werner
Admission Requirements	None
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge Skills	<ul> <li>Students can explain the advantages and shortcomings of the classical gain scheduling approach</li> <li>They can explain the representation of nonlinear systems in the form of quasi-LPV systems</li> <li>They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions</li> <li>They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems</li> <li>They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis technic associated with each of these model structures</li> <li>Students can explain how graph theoretic concepts are used to represent the communication topology of multiage systems</li> <li>They can explain the convergence properties of first order consensus protocols</li> <li>They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models</li> <li>Students can explain concepts behind linear and qLPV Model Predictive Control (MPC)</li> </ul>
	Students can design MPC controllers for linear and non-linear systems using Matlab tools
Personal Competence	
	Students can work in small groups and arrive at joint results.
Autonomy	
,,	given problems.
Workload in Hours	
Credit points	
Course achievement	
Examination	
Examination duration and	
scale	
Assignment for the	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory
Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
	Mechatronics: Specialisation System Design: 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
	Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

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

Course L0662: Advanced 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

Module M0548: Bioel					
Courses					
Title			Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and Applications (L0371)			Lecture	3	5
Bioelectromagnetics: Principles and			Recitation Section (small)	2	1
•	Prof. Christian Schuster				
Admission Requirements					
Kecommended Previous  Knowledge	Basic principles of physics				
Kilowieuge					
Educational Objectives	After taking part successful	lv. students have reache	d the following learning results		
Professional Competence	, inter-tailing part baccessia.	,, stades nave redene	a the fellowing realizing results		
•	Students can explain the ba	sic principles, relationsh	ips, and methods of bioelectromagnet	ics, i.e. the quantific	ation and applicatio
	of electromagnetic fields in	biological tissue. They	can define and exemplify the most in	mportant physical p	henomena and orde
	them corresponding to wa	velength and frequency	of the fields. They can give an over	rview over measure	ment and numerica
	techniques for characteriza	tion of electromagnetic	fields in practical applications . They	can give examples	for therapeutic and
	diagnostic utilization of elec	tromagnetic fields in me	edical technology.		
Skills	Students know how to apply	various methods to cha	aracterize the behavior of electromagn	etic fields in hiologic	ral tissue. In order t
SKIIIS			ementary solutions of Maxwell's Equa		
	*		ological tissue, they can order the e	-	
	· ·	·	n in a quantitative way. They are able		-
	predictions. They are able t	o evaluate the effects of	electromagnetic fields for therapeutic	and diagnostic appl	ications and make a
	appropriate choice.				
Personal Competence					
Social Competence	English (e.g. during small g	-	ted tasks in small groups. They are a	ble to present their	results effectively i
	Linglish (e.g. during sinah g	oup exercises).			
Autonomy	Students are capable to g	ather information from	subject related, professional publicat	ions and relate tha	at information to the
	context of the lecture. The	y are able to make a co	nnection between their knowledge ob	tained in this lectur	e with the content o
	other lectures (e.g. theory	of electromagnetic field	ds, fundamentals of electrical engine	ering / physics). The	ey can communicat
	problems and effects in the	field of bioelectromagne	etics in English.		
	Independent Study Time 11	u, Stuay Time in Lecture	2 / U		
Credit points  Course achievement	6 Compulsory Bonus Form	ı	Description		
course acineveillent		entation	•		
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Spec	ialisation Microwave Fno	gineering, Optics, and Electromagnetic	Compatibility: Elect	ive Compulsorv
Following Curricula		•			
•			isation II. Electrical Engineering: Electi	ve Compulsory	
	Biomedical Engineering: Sp	ecialisation Managemen	t and Business Administration: Elective	e Compulsory	
	Biomedical Engineering: Sp	ecialisation Implants and	l Endoprostheses: Elective Compulsory	,	
	Biomedical Engineering: Sp	ecialisation Artificial Org	ans and Regenerative Medicine: Electi	ve Compulsory	
			nnology and Control Theory: Elective C		
	Theoretical Mechanical Eng	ineering: Specialisation I	Bio- and Medical Technology: Elective	Compulsory	

Course L0371: Bioelectromag	gnetics: Principles and Applications	
Тур	Lecture	
Hrs/wk	3	
СР	5	
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42	
	rof. Christian Schuster	
Language		
Cycle		
Content	- Fundamental properties of electromagnetic fields (phenomena)	
	- Mathematical description of electromagnetic fields (Maxwell's Equations)	
	- Electromagnetic properties of biological tissue	
	- Principles of energy absorption in biological tissue, dosimetry	
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)	
	- Measurement techniques for characterization of electromagnetic fields	
	- Behavior of electromagnetic fields of low frequency in biological tissue	
	- Behavior of electromagnetic fields of medium frequency in biological tissue	
	- Behavior of electromagnetic fields of high frequency in biological tissue	
	- Behavior of electromagnetic fields of very high frequency in biological tissue	
	- Diagnostic applications of electromagnetic fields in medical technology	
	- Therapeutic applications of electromagnetic fields in medical technology	
	- The human body as a generator of electromagnetic fields	
Literature	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)	
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)	
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)	
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)	

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

## **Thesis**

Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	According to Constal Devolutions (21 (1))
	According to General Regulations §21 (1):
	At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous	
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	A The students can use specialized knowledge (fasts, theories, and methods) of their subject competently on specialize
	<ul> <li>The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues.</li> </ul>
	• The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject
	describing current developments and taking up a critical position on them.
	The students can place a research task in their subject area in its context and describe and critically assess the state or
	research.
Skills	The students are able:
	To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question
	• To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/o
	incompletely defined problems in a solution-oriented way.
	To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can
	<ul> <li>Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structure</li> </ul>
	way.
	<ul> <li>Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressee</li> </ul>
	while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able:
	To structure a project of their own in work packages and to work them off accordingly.
	To work their way in depth into a largely unknown subject and to access the information required for them to do so.
	To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	
Course achievement	
Course achievement	
	Thesis
Examination	Thesis According to General Regulations
Examination	
Examination Examination duration and scale	
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## Module Manual M.Sc. "Biomedical Engineering"

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