

# **Module Manual**

Master of Science (M.Sc.)

# Biomedical Engineering Dual study program

Cohort: Winter Term 2022

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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.

In addition to the foundational curriculum taught at TUHH, seminars on developing personal skills are integrated into the dual study programme, in the context of transfer between theory and practice. These seminars correspond to the modern professional requirements expected of an engineer, as well as promoting the link between the two places of learning.

The intensive dual courses at TUHH integrating practical experience consist of an academic-oriented and a practice-oriented element, which are completed at two places of learning. The academic-oriented element comprises study at TUHH. The practice-oriented element is coordinated with the study programme in terms of content and time, and consists of practical modules and phases spent in an affiliate company during periods when there are no lectures.

#### **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.

In addition, students acquire basic professional and personal skills as part of the dual study programme that enable them to enter professional practice at an early stage and to go on to further study. Students also gain practical work experience through the integrated practical modules. Graduates of the dual course have broad foundational knowledge, fundamental skills for academic work and relevant personal competences.

#### 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", "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.

By continually switching places of learnings throughout the dual study programme, it is possible for theory and practice to be interlinked. Students reflect theoretically on their individual professional practical experience, and apply the results of their reflection to new forms of practice. They also test theoretical elements of the course in a practical setting, and use their findings as a stimulus for theoretical debate.

# **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 M1173: Applie	ed Statistics			
Courses				
Title		Тур	Hrs/wk	СР
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Project-/problem-based Learning	2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of statistical methods			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached the follow	wing learning results		
Professional Competence				
Knowledge	Students can explain the statistical methods and the condition	s of their use.		
Skills	Students are able to use the statistics program to solve statist	ics problems and to interpret and o	depict the resu	ults
Personal Competence				
Social Competence	Team Work, joined presentation of results			
Autonomy	To understand and interpret the question and solve			
	7			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes, 28 questions			
scale				
Assignment for the	Mechanical Engineering and Management: Specialisation Mana	agement: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Elective Compuls	ory		
	Mechatronics: Specialisation Intelligent Systems and Robotics:	Elective Compulsory		
	Biomedical Engineering: Core Qualification: Compulsory			
	Product Development, Materials and Production: Core Qualifica	ation: Elective Compulsory		
	Theoretical Mechanical Engineering: Specialisation Bio- and Me	edical Technology: Elective Compu	Isory	

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

Course L1586: Applied Statistics	
Тур	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

Module M1759: Linkir	ng theory and practice (dual study program, Master's degree)
Module Responsible	Dr. Henning Haschke
Admission Requirements	None
Recommended Previous Knowledge	Successful completion of practical modules as part of the dual Bachelor's course     Module "interlinking theory and practice as part of the dual Master's course"
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	Dual students
	can describe and classify selected classic and current theories, concepts and methods
	related to project management and
	change and transformation management
	and apply them to specific situations, processes and plans in a personal, professional context.
Skills	Dual students
	<ul> <li> anticipate typical difficulties, positive and negative effects, as well as success and failure factors in the engineering sector, evaluate them and consider promising strategies and courses of action.</li> <li> develop specialised technical and conceptual skills to solve complex tasks and problems in their professional field o activity/work.</li> </ul>
Personal Competence	
Social Competence	Dual students
	<ul> <li> can responsibly lead interdisciplinary teams within the framework of complex tasks and problems.</li> <li> engage in sector-specific and cross-sectoral discussions with experts, stakeholders and staff, representing their approaches, points of view and work results.</li> </ul>
Autonomy	Dual students
	<ul> <li> define, reflect and evaluate goals and measures for complex application-oriented projects and change processes.</li> <li> shape their professional area of responsibility independently and sustainably.</li> <li> take responsibility for their actions and for the results of their work.</li> </ul>
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and	Studienbegleitende und semesterübergreifende Dokumentation: Die Leistungspunkte für das Modul werden durch die Anfertigung
scale	eines digitalen Lern- und Entwicklungsberichtes (E-Portfolio) erworben. Dabei handelt es sich um eine fortlaufende Dokumentation und Reflexion der Lernerfahrungen und der Kompetenzentwicklung im Bereich der Personalen Kompetenz.

# Courses

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

Module M1756: Pract	ical module 1 (dual study program, Master's degree)
Courses	
Title	Typ Hrs/wk CP
Practical term 1 (dual study progra  Module Responsible	
Admission Requirements	
Recommended Previous	
Knowledge	<ul> <li>Successful completion of a compatible dual B.Sc. at TU Hamburg or comparable practical work experience and competences in the area of interlinking theory and practice</li> </ul>
	Course D from the module on interlinking theory and practice as part of the dual Master's course
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Dual students
	• combine their knowledge of facts, principles, theories and methods gained from previous study content with acquired
	practical knowledge - in particular their knowledge of practical professional procedures and approaches, in the current field of activity in engineering.
	have a critical understanding of the practical applications of their engineering subject.
Skills	Dual students
SKIIIS	
	<ul> <li> apply technical theoretical knowledge to complex, interdisciplinary problems within the company, and evaluate the associated work processes and results, taking into account different possible courses of action.</li> </ul>
	implement the university's application recommendations with regard to their current tasks.
	• develop solutions as well as procedures and approaches in their field of activity and area of responsibility.
Personal Competence	
Social Competence	Dual students
	• work responsibly in project teams within their working area and proactively deal with problems within their team.
	• represent complex engineering viewpoints, facts, problems and solution approaches in discussions with internal and
	external stakeholders.
Autonomy	Dual students
	define goals for their own learning and working processes as engineers.
	reflect on learning and work processes in their area of responsibility.
	<ul> <li> reflect on the relevance of subject modules specialisations and specialisation for work as an engineer, and also implement the university's application recommendations and the associated challenges to positively transfer knowledge</li> </ul>
	between theory and practice.
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Credit points	
Course achievement	
	Written elaboration  Documentation accompanying studies and across semesters: Module credit points are earned by completing a digital learning and
	development report (e-portfolio). This documents and reflects individual learning experiences and skills development relating to
	interlinking theory and practice, as well as professional practice. In addition, the partner company provides proof to the
	dual@TUHH Coordination Office that the dual student has completed the practical phase.
•	Civil Engineering: Core Qualification: Compulsory
Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory
	Computer Science: Core Qualification: Compulsory
	Electrical Engineering: Core Qualification: Compulsory
	Energy Systems: Core Qualification: Compulsory  Environmental Engineering: Core Qualification: Compulsory
	Aircraft Systems Engineering: Core Qualification: Compulsory
	Computer Science in Engineering: Core Qualification: Compulsory
	Information and Communication Systems: Core Qualification: Compulsory International Management and Engineering: Core Qualification: Compulsory
	Logistics, Infrastructure and Mobility: Core Qualification: Compulsory
	Materials Science: Core Qualification: Compulsory
	Mechanical Engineering and Management: Core Qualification: Compulsory
	Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Core Qualification: Compulsory
	Microelectronics and Microsystems: Core Qualification: Compulsory
	Product Development, Materials and Production: Core Qualification: Compulsory
	Renewable Energies: Core Qualification: Compulsory  Naval Architecture and Ocean Engineering: Core Qualification: Compulsory
	Theoretical Mechanical Engineering: Core Qualification: Compulsory
	Process Engineering: Core Qualification: Compulsory

Water and Environmental Engineering: Core Qualification: Compulsory

Course L2887: Practical term	1 (dual study program, Master's degree)
Тур	
Hrs/wk	0
СР	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	Company onboarding process
	<ul> <li>Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work</li> <li>Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.)</li> <li>Working independently in a team and on selected projects - across departments and, if applicable, across companies</li> <li>Scheduling the current practical module with a clear correlation to work structures</li> <li>Scheduling the examination phase/subsequent study semester</li> <li>Operational knowledge and skills</li> <li>Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions</li> <li>Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity</li> <li>Systemic skills</li> <li>Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company</li> </ul>
	Sharing/reflecting on learning
	<ul> <li>Creating an e-portfolio</li> <li>Importance of course contents (M.Sc.) when working as an engineer</li> <li>Importance of development and innovation when working as an engineer</li> </ul>
Literature	<ul> <li>Studierendenhandbuch</li> <li>Betriebliche Dokumente</li> <li>Hochschulseitige Handlungsempfehlungen zum Theorie-Praxis-Transfer</li> </ul>

Module M0811: Medio	cal Imaging Systems
Courses	
Title	Typ Hrs/wk CP
Medical Imaging Systems (L0819)	Lecture 4 6
Module Responsible	Dr. Michael Grass
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	
	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;
	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:
	a Understand which physical offects are used in medical imaging.
	<ul> <li>Understand which physical effects are used in medical imaging;</li> <li>Decide independently for which clinical issue a measuring system can be used.</li> </ul>
	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	6
Course achievement	None
Examination	Written exam
Examination duration and	90 min
scale	
Assignment for the	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
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
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

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

Courses				
Fitle	ant Matarials and Bardonking (13566)	Тур	Hrs/wk	СР
Module Responsible	ent, Materials and Production (L1566)	Practical Course	6	6
Admission Requirements				
Recommended Previous				
Knowledge	Lectures: Mechanics I-III     Lectures: Integrated Product Developmen  Materials:     Lectures: Structural Metallic Materials, Me     Lectures: Structure and Properties of Po     Composites  Production:     Lecture: Production Engineering     Lectures: Forming and Cutting Technology     Lectures: Machine Tools and Robotic	tallic Materials for Aircraft Applications, Ir lymers, Structure and Properties of Com		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
<b>Professional Competence</b>				
Knowledge	represent more complex context of differe     describe functionality of modern measure		nologies.	
Skills	Students are capable of  applying theoretical knowledge for practice applying provided experimental methods analyzing and evaluating experimental ree applying modern measurement instrumental received.	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			
Autonomy	Students are able to     carry out parts of experimental work independence of the 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	ire 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 Course Product Development, Materials and Production			
Тур	Practical Course		
Hrs/wk	6		
СР	6		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Lecturer	Prof. Wolfgang Hintze, Prof. Josef Schlattmann, Prof. Dieter Krause, Prof. Claus Emmelmann, Prof. Bodo Fiedler, Prof. Hermann		
	Lödding, Prof. Michael Morlock, Prof. Gerold Schneider, Prof. Thorsten Schüppstuhl, Prof. Otto von Estorff, Prof. Jörg Weißmüller		
Language	DE		
Cycle	SoSe		
Content	Product Development:		
	<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>		
	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 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	Dr. Peter Hübener			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in Le	ecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 minutes			
scale				
Assignment for the	International Management and Engineering: 9	Specialisation II. Process Engineering and	Biotechnology: Elective	Compulsory
Following Curricula	Biomedical Engineering: Core Qualification: C	ompulsory		

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 Basic	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. Kevin Roedl		
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.		

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				
Admission Requirements				
	The lectures addressing medical issues from the	concentration Biomedical Engineering in	the respective BSc P	rograms.
Knowledge				
	After taking part successfully, students have rea	sched the following learning results		
Professional Competence				
Knowledge	The students learn the process of clinical practic			·
	surgical and medical diseases in the various de	partments, 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	and medical records of a patient.		
	Dealing with patients.			
Personal Competence				
Social Competence	Dealing with patients.			
Autonomy				
Workload in Hours	Independent Study Time 96, Study Time in Lect	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and	5 Pages (10 Case studies)			
scale				
Assignment for the	Biomedical Engineering: Core Qualification: Com	npulsory		
Following Curricula				

Course L1603: Casestudies S	urgery and Internal Medicine		
	Seminar		
Hrs/wk			
СР			
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 M1757: Pract	ical module 2 (dual study pro	gram, Master's degree)	
Courses			
Title		Тур	Hrs/wk CP
Practical term 2 (dual study progra			0 10
Module Responsible	, , , , , , , , , , , , , , , , , , ,		
Admission Requirements  Recommended Previous	None		
Knowledge	Successful completion of practical m	odule 1 as part of the dual Master's course	
	course D from the module on interlin	nking theory and practice as part of the dual	Master's course
Educational Objectives	After taking part successfully, students hav	ve reached the following learning results	
Professional Competence			
Knowledge	Dual students		
	practical knowledge - in particular the of activity in engineering.	s, principles, theories and methods gained neir knowledge of practical professional proc ne practical applications of their engineering	edures and approaches, in the current fie
Skills	Dual students		
	associated work processes and resul     implement the university's applica     develop (new) solutions as well	vledge to complex, interdisciplinary probler lts, taking into account different possible cou ation recommendations with regard to their of as procedures and approaches in their fin nanging requirements (systemic skills).	rses of action. current tasks.
Personal Competence			
Social Competence	Dual students		
	• work responsibly in cross-depart	mental and interdisciplinary project teams	and proactively deal with problems with
	their team.		
	represent complex engineering external stakeholders and develop to	viewpoints, facts, problems and solution aphese further together.	oproaches in discussions with internal a
Autonomy	Dual students		
	define goals for their own learning	and working processes as anginous	
	reflect on learning and work proce		
	reflect on the relevance of sub-	oject modules specialisations and specialision recommendations and the associated c	
	between theory and practice.		
Workload in Hours	Independent Study Time 300, Study Time i	n Lecture 0	
Credit points	10		
Course achievement	None		
Examination	Written elaboration		
Examination duration and scale	development report (e-portfolio). This docuinterlinking theory and practice, as well	across semesters: Module credit points are uments and reflects individual learning exp as professional practice. In addition, the ual student has completed the practical phas	eriences and skills development relating e partner company provides proof to the
Assignment for the	Civil Engineering: Core Qualification: Comp	ulsory	
Following Curricula			
	Chemical and Bioprocess Engineering: Core		
	Computer Science: Core Qualification: Com Electrical Engineering: Core Qualification: C		
	Energy Systems: Core Qualification: Compu		
	Environmental Engineering: Core Qualificat		
	Aircraft Systems Engineering: Core Qualific	ation: Compulsory	
	Computer Science in Engineering: Core Qua		
	Information and Communication Systems:		
	International Management and Engineering Logistics, Infrastructure and Mobility: Core		
	Materials Science: Core Qualification: Comp	• •	
	Mechanical Engineering and Management:		
	Mechatronics: Core Qualification: Compulso	pry	
	Biomedical Engineering: Core Qualification:		
	Microelectronics and Microsystems: Core Q Product Development, Materials and Product	• •	
	Renewable Energies: Core Qualification: Co		
	Naval Architecture and Ocean Engineering:	• •	
	Theoretical Mechanical Engineering: Core C		

Process Engineering: Core Qualification: Compulsory
Water and Environmental Engineering: Core Qualification: Compulsory

Course L2888: Practical term	n 2 (dual study program, Master's degree)
Тур	
Hrs/wk	0
СР	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	Company onboarding process
	<ul> <li>Assigning a professional field of activity as an engineer (B.Sc.) and associated fields of work</li> <li>Establishing responsibilities and authorisation of the dual student within the company as an engineer (B.Sc.)</li> <li>Taking personal responsibility within a team and on selected projects - across departments and, if applicable, across companies</li> <li>Scheduling the current practical module with a clear correlation to work structures</li> <li>Scheduling the examination phase/subsequent study semester</li> <li>Operational knowledge and skills</li> <li>Company-specific: Responsibility as an engineer (B.Sc.) in their own area of work, coordinating team and project work, dealing with complex contexts and unsolved problems, developing and implementing innovative solutions</li> <li>Subject specialisation (corresponding to the chosen course [M.Sc.]) in the field of activity</li> <li>Systemic skills</li> <li>Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company</li> </ul>
	Sharing/reflecting on learning  Updating their e-portfolio Importance of course contents (M.Sc.) when working as an engineer Importance of development and innovation when working as an engineer
Literature	Studierendenhandbuch     Betriebliche Dokumente     Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer

Module M1214: Study	/ 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	

	cical module 3 (dual study progi	ani, musici s'acgree,		
Courses				
Title	Macharla danna (12000)	Тур	Hrs/wk	CP
Practical term 3 (dual study progra  Module Responsible			0	10
Admission Requirements	-			
Recommended Previous				
Knowledge	<ul> <li>Successful completion of practical mod</li> </ul>	lule 2 as part of the dual Master's course		
	course E from the module on interlinking	ng theory and practice as part of the dua	l Master's course	
Educational Objectives	After taking part successfully, students have	reached the following learning results		
<b>Professional Competence</b>				
Knowledge	Dual students			
	<ul> <li> combine their comprehensive and strategy-oriented practical knowledge</li> <li> have a critical understanding of th implementing innovations.</li> </ul>	gained from their current field of work an	nd area of responsibility.	
Skills	Dual students			
	implement the university's applicati     develop new solutions as well as pr     when facing frequently changing requi	s and results, taking into account different on recommendations with regard to their	nt possible courses of according transfer courrent tasks.  operational projects and temic skills).	tion. d assignments - eve
Personal Competence	,			
Social Competence	Dual students			
	work responsibly in cross-department	antal and interdisciplinary project teams	s and proactively deal a	with problems withi
	their team.  • can promote the professional develo  • represent complex and interdiscipli with internal and external stakeholders	nary engineering viewpoints, facts, prob	lems and solution appro	aches in discussion
Autonomy	Dual students			
	<ul> <li> reflect on learning and work process</li> <li> define goals for new application-orion company and the public.</li> <li> reflect on the relevance of areas university's application recommendation and practice.</li> </ul>	ented tasks, projects and innovation plar	k as an engineer, and	also implement th
Workload in Hours	Independent Study Time 300, Study Time in I	_ecture 0		
Credit points	10			
Course achievement				
Examination	Written elaboration			
Examination duration and scale		nents and reflects individual learning ex s professional practice. In addition, th	periences and skills dev ne partner company pr	elopment relating
Assignment for the	Civil Engineering: Core Qualification: Compuls	sory		
Following Curricula	Bioprocess Engineering: Core Qualification: C	ompulsory		
	Chemical and Bioprocess Engineering: Core C			
	Computer Science: Core Qualification: Compu	•		
	Electrical Engineering: Core Qualification: Core			
	Energy Systems: Core Qualification: Compuls			
	Environmental Engineering: Core Qualification Aircraft Systems Engineering: Core Qualification			
	Computer Science in Engineering: Core Qualification			
	Information and Communication Systems: Co			
	International Management and Engineering: (	Core Qualification: Compulsory		
	International Management and Engineering: 0	ualification: Compulsory		
	International Management and Engineering: C Logistics, Infrastructure and Mobility: Core Qu	ualification: Compulsory sory pre Qualification: Compulsory		

Biomedical Engineering: Core Qualification: Compulsory

Microelectronics and Microsystems: Core Qualification: Compulsory

Product Development, Materials and Production: Core Qualification: Compulsory

Renewable Energies: Core Qualification: Compulsory

Naval Architecture and Ocean Engineering: Core Qualification: Compulsory
Theoretical Mechanical Engineering: Core Qualification: Compulsory

Process Engineering: Core Qualification: Compulsory

Water and Environmental Engineering: Core Qualification: Compulsory

Course L2889: Practical term	n 3 (dual study program, Master's degree)
Тур	
Hrs/wk	0
СР	10
Workload in Hours	Independent Study Time 300, Study Time in Lecture 0
Lecturer	Dr. Henning Haschke
Language	DE
Cycle	WiSe/SoSe
Content	Company onboarding process
	<ul> <li>Assigning a future professional field of activity as an engineer (M.Sc.) and associated fields of work</li> <li>Extending responsibilities and authorisation of the dual student within the company up to the intended first assignment after completing their studies</li> <li>Working responsibly in a team; project responsibility within own area - as well as across divisions and companies if necessary</li> <li>Scheduling the final practical module with a clear correlation to work structures</li> <li>Internal agreement on a potential topic or innovation project for the Master's dissertation</li> <li>Planning the Master's dissertation within the company in cooperation with TU Hamburg</li> <li>Scheduling the examination phase/subsequent study semester</li> </ul>
	Operational knowledge and skills
	<ul> <li>Company-specific: dealing with change, project and team development, responsibility as an engineer in their future field of work (M.Sc.), dealing with complex contexts, frequent and unpredictable changes, developing and implementing innovative solutions</li> <li>Specialising in one field of work (final dissertation)</li> <li>Systemic skills</li> <li>Implementing the university's application recommendations (theory-practice transfer) in corresponding work and task areas across the company</li> </ul>
	Sharing/reflecting on learning
	<ul> <li>E-portfolio</li> <li>Relevance of study content and personal specialisation when working as an engineer</li> <li>Relevance of research and innovation when working as an engineer</li> </ul>
Literature	<ul> <li>Studierendenhandbuch</li> <li>betriebliche Dokumente</li> <li>Hochschulseitige Anwendungsempfehlungen zum Theorie-Praxis-Transfer</li> </ul>

# **Specialization Implants and Endoprostheses**

Module M0623: Intell	igent Systems	in Medicine				
Courses						
Title				Тур	Hrs/wk	CP
Intelligent Systems in Medicine (L0				Lecture	2	3
Intelligent Systems in Medicine (L0				Project Seminar	2	2
Intelligent Systems in Medicine (L0				Recitation Section (small)	1	1
Module Responsible		efer				
Admission Requirements	None					
Recommended Previous	principles of m	ath (algebra, analysis/ca	lculus)			
Knowledge	principles of st		,			
		rogramming, Java/C++ ar	nd R/Matlab			
	advanced proc					
Educational Objectives	After taking part succ	cessfully, students have r	eached the followi	ng learning results		
Professional Competence						
Knowledge				lanning and decision suppor		
				r classification and their resp		
				Is for representing medical k		
		•	allenges due to th	e clinical nature of the data	and its acquisition	and due to privacy
	and safety requireme	ents.				
Skills	The students can giv	e reasons for selecting a	ind adapting meth	ods for classification, regres	ssion, and predicti	on. They can assess
	the methods based o	n actual patient data and	evaluate the impl	emented methods.		
Davagnal Compotones						
Personal Competence Social Competence	The students are ab	lo to grace practical tack	rs in groups, dove	lop solution strategies indep	andontly define	work processes and
30ciai competence			in groups, deve	nop solution strategies indep	benderitiy, denne	work processes and
	work on them collaboratively.  The students can critically reflect on the results of other groups, make constructive suggestions for improvement and also					
	incorporate them into		saits of other given	oups, make constructive su	iggestions for imp	novement and also
Autonomy	The students can ass	ess their level of knowled	lge and document	their work results. They can	critically evaluate	the results achieved
,		an appropriate argument			, , , , , , , , ,	
				3		
Workload in Hours	Independent Study T	ime 110, Study Time in L	ecture 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	Computer Science: S	pecialisation II: Intelligend	ce Engineering: Ele	ective Compulsory		
Following Curricula	Electrical Engineering	g: Specialisation Medical <sup>-</sup>	Technology: Electi	ve Compulsory		
	Interdisciplinary Math	nematics: Specialisation C	Computational Met	hods in Biomedical Imaging:	Compulsory	
	·	lisation Intelligent Systen				
	_	• .	-	enerative Medicine: Elective	Compulsory	
	3	J , ,	·	eses: Elective Compulsory		
	_	• .		Control Theory: Elective Com		
	3	3 1		ss Administration: Elective Co	. ,	
	Theoretical Mechanic	al Engineering: Specialisa	ation Bio- and Med	ical Technology: Elective Cor	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	

Courses				
Гitle		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	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 Appr	oval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomech	anics (L0377)	Lecture	2	3
Experimental Methods for the Cha	acterization of Materials (L1580)	Lecture	2	2
Numerical Methods in Biomechanic	:s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (I	.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
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				
	Depends on choice of courses			
Workload in Hours	6			
Workload in Hours  Credit points	1 -	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
		Endoprostheses: Elective Compulsory		
Credit points Assignment for the			pulsory	
Credit points Assignment for the	Biomedical Engineering: Specialisation Implants and E	nology and Control Theory: Elective Com		

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

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

Course L1588: Development	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		
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	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical	
	knowledge is provided.	
	1. Tribology	
	2. Optical Methods	
	3. Motion Analysis	
	4. Pressure Distribution	
	5. Strain Gauges	
	6. Pre-clinical testing	
	7. Specimen Preparation and Storage	
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen	
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine	
	Nigg, B.: Biomechanics of the musculo-skeletal system	
	Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/	

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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).

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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Tom	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 Decree 11 County of Fine house and Mahambara to Fine house the fine house for the house for the fine house for the fine house for the fine house	
	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, Dr. Johannes Brunnemann	
Language	DE	
Cycle	WiSe	
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.	
	<ul> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example:Hydraulic systems and heat transfer</li> <li>Example: System with different subsystems</li> </ul>	
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		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 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	2
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
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	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	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: 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	3	
СР	4	
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42	
Examination Form	Mündliche Prüfung	
Examination duration and	30 min	
scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	SoSe	
	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well of 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 propagation and Electromagnetic Compatibility will be introduced and discussed.  Topics:  - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - 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	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical
	knowledge is provided.
	1. Tribology
	2. Optical Methods
	3. Motion Analysis
	4. Pressure Distribution
	5. Strain Gauges
	6. Pre-clinical testing
	7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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	Dr. Gerd Huber, Prof. Michael Morlock			
Language	DE			
Cycle	WiSe			
Content				
Literature	Keine			

Course 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 Wave-Turbines - Renewable Energy
	Introduction into Computational Fluid Dynamics
Literature	
	Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.      Brauer, H.: Mause, D.: Staffaustagen einerhändlich ebersieden Bestäten. Frankfurt (Sauerländer, 1973).
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	<ol> <li>Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg</li> </ol>
	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 / GWV
	Fachverlage GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	<ol> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner GWV Fachverlage GmbH, Wiesbaden, 2009.</li> </ol>
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer
	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.
	13. Van Dyke, M., An Album of Fluid Motion. The Farabolic Fress, 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	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 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

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 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				
	different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute th				
		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		

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     Planning
	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	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 Le	ecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Calculus     Linear Algebra     Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the following learning re	esults		
Professional Competence  Knowledge  Skills	<ul> <li>Students are able to denote terms and concepts of Vibration Theory ar</li> <li>Students know methods of modeling and simulation for free, driven, se</li> <li>Students know about concepts of linear and nonlinear vibration probler</li> <li>Students know basic tasks of vibration problems of discrete and contin</li> </ul>	elf-excited and parar		orations.
JAIIS	<ul> <li>Students are able to denote methods of Vibration Theory and develope</li> <li>Students are able to apply and expand methods of modeling and sindriven vibrations.</li> <li>Students are able to solve linear and nonlinear vibration problems.</li> </ul>		orced, self-excit	ed and parameter
Personal Competence Social Competence Autonomy	Students can analyze vibration problems, work on them, and reach work     Students are able to document the results of vibration studies also in g	roups.	teams or group	s.
	Students are able to approach individually research tasks in Vibration 7	Γheory.		
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 Following Curricula		dicine: Elective Come compulsory ry: Elective Compuls tion: Elective Comp	ory	
	Naval Architecture and Ocean Engineering: Core Qualification: Elective Computer Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory	•		

Course L0701: Vibration The	ory				
Тур	Integrated Lecture				
Hrs/wk					
СР	6				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Lecturer	Prof. Norbert Hoffmann				
Language	DE/EN				
Cycle	WiSe				
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations  Free vibration Self-excited vibration Parameter driven vibration Forced vibration Multi degree of freedom vibration Continuum vibration				
Literature	• Irregular vibration  German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen.  English - K. Magnus: Vibrations.				

Module M0808: Finite	Elements Methods			
Courses				
		Tim	Han buls	CD
Title Finite Element Methods (L0291)		<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
	Prof. Otto von Estorff	recitation section (large)		
Module Responsible				
Admission Requirements				
Recommended Previous	(11)	als) and Mechanics II (Hydrostatics, Kinematics, Dyna	amics)	
Knowledge	Mathematics I, II, III (in particular different	tial equations)		
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowl	ledge regarding the derivation of the finite eleme	ent method and	are able to give
	overview of the theoretical and methodical			, , , , , , , , , , , , , , , , , , ,
Skills		neering problems by formulating suitable finite eler	ments, assemblir	ig the correspondi
	system matrices, and solving the resulting	g system of equations.		
Personal Competence				
Social Competence	Students can work in small groups on spe	cific problems to arrive at joint solutions.		
Autonomy	The students are able to independently	solve challenging computational problems and c	levelop own finit	te element routin
-	Problems can be identified and the results			
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
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: Com	pulsory		
Following Curricula	Energy Systems: Core Qualification: Electi	ive Compulsory		
	Aircraft Systems Engineering: Core Qualifi	ication: Elective Compulsory		
	International Management and Engineerin	ng: Specialisation II. Mechatronics: Elective Compulse	ory	
	International Management and Engineerin	ng: Specialisation II. Product Development and Produ	iction: Elective Co	ompulsory
	Mechatronics: Core Qualification: Compuls	sory		
	Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Me	edical Technology and Control Theory: Elective Com	oulsory	
	Biomedical Engineering: Specialisation Art	tificial Organs and Regenerative Medicine: Elective (	Compulsory	
	Product Development, Materials and Product	uction: Core Qualification: Compulsory		
	l e e e e e e e e e e e e e e e e e e e			
	Technomathematics: Specialisation III. En	gineering 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	t Methods
Тур	Recitation Section (large)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0814: Techr	nology Management			
Courses				
Title		Тур	Hrs/wk	СР
Technology Management (L0849)		Lecture	3	3
Technology Management Seminar	(L0850)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements				
	Bachelor knowledge in business management			
Knowledge	After taking part successfully, students have reached the fell	owing learning regults		
Professional Competence	After taking part successfully, students have reached the following taking ta	owing learning results		
	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies	(100)		
	Technology Strategies and Lifecycle Manageme     Technology Intelligence and Planning	nt (I/II)		
	<ul> <li>Technology Intelligence and Planning</li> <li>Technology Portfolio Management</li> </ul>			
	Technology Portfolio Methodology			
	Technology Acquisition and Exploitation			
	IP Management			
	Organizing Technology Development			
	<ul> <li>Technology Organization &amp; Management</li> </ul>			
	<ul> <li>Technology Funding &amp; Controlling</li> </ul>			
Skills	The course aims to:			
	Develop an understanding of the importance of Technol	ology Management - on a national a	s well as interi	national level
	Equip students with an understanding of importa			
	organizational and process-related aspects)			
	Foster a strategic orientation to problem-solving within	n the innovation process as well as	s Technology N	Management and its
	importance for corporate strategy			
	<ul> <li>Clarify activities of Technology Management (e.g. tech</li> </ul>	nology sourcing, maintenance and	exploitation)	
	Strengthen essential communication skills and a base			and financial issues
	concerning Technology-, Innovation- and R&D-manage	ment. 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			
	<ul> <li>Gain access to knowledge sources</li> <li>Discuss recent research debates in the context of Tech</li> </ul>	nnology and Innovation Managemen	t	
	Develop presentation skills	mology and importation management		
	Discussion of international cases in R&D-Management			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the	Global Innovation Management: Core Qualification: Compulso	pry		
Following Curricula	•	•	mpulsory	
-	Mechanical Engineering and Management: Specialisation Mar	nagement: Elective Compulsory	-	
	Biomedical Engineering: Specialisation Artificial Organs and R	Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endopro	stheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology at		sory	
	Biomedical Engineering: Specialisation Management and Bus	iness Administration: Compulsory		

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	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			
Γitle	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, mechanics and semiconductor technology		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Students are able		
	• to present and to explain current fabrication techniques for microstructures and especia microsensors and microactuators, as well as the integration thereof in more complex systems	lly methods	for the fabrication
	to explain in details operation principles of microsensors and microactuators and		
	to discuss the potential and limitation of microsystems in application.		
Skills	Students are capable		
	to analyze the feasibility of microsystems,		
	to develop process flows for the fabrication of microstructures and		
	to apply them.		
Personal Competence			
Social Competence			
	Students are able to plan and carry out experiments in groups, as well as present and repres		
	These social skills are practiced both during the preparation phase, in which the groups work during the follow-up phase, in which the groups prepare, document and present their practical expenses the property of the prope		sent the theory, a
	during the follow-up phase, in which the groups prepare, document and present their practical ex	cperiences.	
Autonomy	The independence of the students is demanded and promoted in that they have to transfer any	المطابد بالممد	thay baya laaraad
Autonomy	The independence of the students is demanded and promoted in that they have to transfer and ever new boundary conditions. This requirement is communicated at the beginning of the semes		
	the exam. Students are encouraged to work independently by not being given a solution, but by		
	step by step by asking specific questions. Students learn to ask questions independently whe	-	
	They learn to independently break down problems into manageable sub-problems.	in circy are it	reed with a proble
	They really a real down problems into manageable sub-problems.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	Compulsory Bonus Form Description		
	Yes None Subject theoretical andStudierenden führen in Kleingruppen ein La	borpraktikum	durch. Jede Grup
	practical work präsentiert und diskutiert die Theorie sowie o	die Ergebniise	e ihrer Labortätigke
	vor dem gesamten Kurs.		
Examination	Oral exam		
Examination duration and	30 min		
scale			
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Con	mpulsory	
Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory		
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compuls		
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Comp		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Com	npulsory	
	Microelectronics and Microsystems: Core Qualification: Elective Compulsory		

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

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

ourses				
itle		Тур	Hrs/wk	CP
ontrol Systems Theory and Desig ontrol Systems Theory and Desig		Lecture Recitation Section (small)	2	4 2
		Recitation Section (Smail)	2	2
Module Responsible				
Admission Requirements				
Knowledge	Introduction to Control Systems			
Educational Objectives		eached the following learning results		
Professional Competence		eached the following learning results		
Knowledge				
		nic systems are represented as state space r	nodels; they can	interpret the syst
	response to initial states or external exc			
		s controllability and observability, and their re	lationship to state	e feedback and st
	estimation, respectively	sinimal raplication		
	They can explain the significance of a m     They can explain observer based state in	nnimai realisation feedback and how it can be used to achieve tra	acking and disturb	ance rejection
	They can extend all of the above to mul		acking and distur	dance rejection
		s relationship with the Laplace Transform		
	· ·	nd transfer function models of discrete-time sys	stems	
		tification of ARX models of dynamic systems, a		ification problem o
	be solved by solving a normal equation			
	They can explain how a state space mo	del can be constructed from a discrete-time im	pulse response	
Skills				
SKIIIS		n models into state space models and vice ver	sa	
	They can assess controllability and observed.	ervability and construct minimal realisations		
	They can design LQG controllers for mu			
		both in continuous-time and discrete-time dor	nain, and decide	which is appropri
	for a given sampling rate			
		els and state space models of dynamic system ng standard software tools (Matlab Control To		
	Simulink)	ing standard software tools (Matian Control it	oolbox, System it	lentineation looibe
B 16				
Personal Competence				
Social Competence	Students can work in small groups on specific	problems to arrive at joint solutions.		
Autonomy	Students can obtain information from provide	ed sources (lecture notes, software documen	tation, experimer	nt guides) and use
	when solving given problems.			
	They can assess their knowledge in weekly on	line tests and thereby central their learning pu	rogroce	
	They can assess their knowledge in weekly on	-ine tests and thereby control their learning pr	ogress.	
Workload in Hours	, , ,	ecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Electrical Engineering: Core Qualification: Com	pulsory		
Following Curricula	Energy Systems: Core Qualification: Elective C	ompulsory		
	Aircraft Systems Engineering: Core Qualification	on: Elective Compulsory		
	Computer Science in Engineering: Specialisation			
	International Management and Engineering: S			
	International Management and Engineering: S			
	Mechanical Engineering and Management: Spe	ecialisation Mechatronics: Elective Compulsory		
	Mechatronics: Core Qualification: Compulsory	John St. H. S. C.	C	
	Biomedical Engineering: Specialisation Artificia	•	Compulsory	
	Biomedical Engineering: Specialisation Implant Biomedical Engineering: Specialisation Medica			
	Biomedical Engineering: Specialisation Manage		ompulsory	
	Product Development, Materials and Production		pa501 <b>y</b>	
	Theoretical Mechanical Engineering: Core Qua			

-	Lacture
	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	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)		Recitation Section (small)  Recitation Section (small)	1	1 1
xercise: The Digital Enterprise (LC		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		
-	Students can explain the contents of the module in detail and take a critical position to them.  Students are capable of choosing and applying models and methods from the module to industrial problems.			
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				
-	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: 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	terprise
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Robert Rost
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 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	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. Robert Rost	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses				
Courses				
<b>Title</b> Continuum Mechanics (L1533)	Ту	<b>p</b> cture	Hrs/wk 2	<b>CP</b> 3
Continuum Mechanics (£1333)  Continuum Mechanics Exercise (£1		citation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
· · · · · · · · · · · · · · · · · · ·	Basics of mechanics as taught, e.g., in the modules Engineering N	lechanics I and Engineerin	g Mechanics II	at TUHH (forces an
Knowledge				
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
Educational Objectives	After taking part successfully, students have reached the following I	earning results		
Professional Competence				
Knowledge	In this module, students learn the fundamental concepts of nonl			
	describe arbitrary deformations of continuous bodies (solid, liquid o	,		
	of the basic module Engineering Mechanics II (elastostatics), the li small deformations, simple geometries) of which are successively el		pic, iiriear-eiasc	ic material behavio
	shall deformations, simple geometries, or which are successively en	illinated.		
	First, the students learn the necessary fundamentals of tensor calcu			
	of arbitrarily deformable bodies is dealt with. The students learn the			-
	a body and for formulating the balance equations for mass, mome students know which constitutive assumptions have to be made for			
	students know which constitutive assumptions have to be made for	modeling the material ben	avior or a meen	arricar body.
a				
SKIIIS	The students can set up balance laws and apply basics of deformatives research contexts.	ition theory to specific asp	ects, both in a	oplied contexts as
	research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions also for complex probler	ns of solid mechanics, to p	resent them to	specialists in writte
	form and to develop ideas further.			
4.4		- <del>-</del>		
Autonomy	The students are able to assess their own strengths and weaknesse problems in the area of continuum mechanics and acquire the know		and on their ov	vn identity and solv
	problems in the area of continuum mechanics and acquire the know	leage required to this end.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination				
Examination duration and				
scale				
Assignment for the		Elective Compulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Mechatronics: Technical Complementary Course: Elective Compulso			
	Biomedical Engineering: Specialisation Artificial Organs and Regene	•	ompulsorv	
	Biomedical Engineering: Specialisation Implants and Endoprosthese:		F - ==: J	
	Biomedical Engineering: Specialisation Medical Technology and Con		ulsory	
	Biomedical Engineering: Specialisation Management and Business A	dministration: Elective Cor	npulsory	
	Product Development, Materials and Production: Core Qualification:	Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualification: Elective Con	npulsory		

Course L1533: Continuum Mo	echanics
	Lecture
Hrs/wk	
CP	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Christian Cyron
Language	
_	
Content	Wise Continuum mechanics is a general theory to describe the effect of mechanical forces on continuous mechanical (both solid and fluid) bodies. An important part of continuum mechanics is the mathematical description of strains and stresses as well as the stress-strain response of continuous mechanical bodies. The lecture continuum mechanics builds on the foundations tought in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) the focus was by and large limited to small deformations of simple bodies under simple loading, the lecture continuum mechanics introduces a general mathematical framework to deal with arbitrarily shaped bodies under arbitrarily adding undergoing very general kinds of deformations. This lecture focuses primarily on theoretical spects of continuum and the stress of the stress of the stress of the stress of the stress and simple production, automotive, and biomedical engineering. The lecture covers:  • Fundamentals of tensor calculus  • Transformation invariance  • Tensor algebra  • Tensor algebra  • Tensor algebra  • Tensor analysis  • Kinematics  • Motion of continuum  • Deformation of infinitesimal line, area and volume elements  • Material and spatial description  • Deformation of infinitesimal line, area and volume elements  • Spectral decomposition  • Spectral decomposition  • Objectivity  • Strain measures  • Time derivatives  • Partial / material time derivatives  • Objectivity  • Strain measures  • Transport theorems  • Balance of mass  • The stress state  • Surface traction vectors  • Cauchy's fundamental theorem  • Stress tensors (Gauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)  • Balance of linear momentum  • Balance of ineary  • Balance of entropy  • Clausius-Duhem inequality  • Constit
	Initial-boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
Electature	
	I-S. Liu: Continuum Mechanics, Springer

Course L1534: Continuum Mo	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	The exercise on Continuum Mechanics explains the theoretical content of the lecture on Continuum Mechanics by way of a series of specific example problems.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer

Courses				
<b>Fitle</b> Material Modeling (L1535)	<b>Typ</b> Lecture		Hrs/wk 2	<b>CP</b> 3
Material Modeling (L1535)		ection (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
Recommended Previous	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics	I and Engineer	ing Mechanics II	at TUHH (forces
Knowledge	moments, stress, linear strain, free-body principle, linear-elastic constitutive l	aws, strain ener	gy); basics of ma	thematics as tau
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
Educational Objectives		esults		
Professional Competence		v vissoolostisit	, and claste place	ticity in the reals
Knowieage	The students understand the theoretical foundations of anisotropic elasticity three-dimensional (linear) continuum mechanics. In the area of anisotropic el			
	and its application in orthotropic, transversely isotropic and isotropic mate		•	-
	compliance and how both can be characterized by appropriate parameters. M			
	in the time and frequency domain using the concepts of relaxation modulus,			-
	the area of elasto-plasticity, the students know the concept of yield stress	or (in higher dir	nensions) yield s	urface and of pla
	potential. Additionally, the know the concepts of ideal plasticity, hardening	ng and weaken	ing. Moreover, th	hey know von-M
	plasticity as a specific model of elasto-plasticity.			
Skills	The students can independently identify and solve problems in the area of ma	aterials modelin	g and acquire the	knowledge to do
	This holds in particular for the area fo anisotropically elastic, viscoelastic and			
	students can independently develop models for complex material behavi		-	•
	understand relevant literature and identify the relevant results reported the			
	developed or found in the literature in computational software (e.g., based of calculations.	on the finite ele	ment method) an	id use it for pract
Personal Competence				
Social Competence				
	to discuss challening problems of materials modeling with experts using the proper terminoloy, to identify and ask critical			
	questions in such discussions and to identify and discuss potential caveats in		-	
Autonomy	The students have the ability to independently develop abstract models that	allow them to cl	assify observed p	henomena withir
	more general abstract framework and to predict their further evolution. Mo			3
	also limitations of mathematical models and can thus independently decide v	when and to whi	ch extent they m	ake sense as a b
	for decisions.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement				
Examination				
Examination duration and scale				
	Materials Science: Specialisation Modeling: Elective Compulsory			
Following Curricula		Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Me		Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective		, , ,	
	Biomedical Engineering: Specialisation Medical Technology and Control Theor		pulsory	
	Biomedical Engineering: Specialisation Management and Business Administra	tion: Elective Co	mpulsory	
	Product Development, Materials and Production: Core Qualification: Elective C	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Ele	ective Compulso	rv	

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

Module M1199: Advar	nced Functional Materials			
Courses				
Title		Тур	Hrs/wk	СР
Advanced Functional Materials (L16	525)	Seminar	2	6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/I	l		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ving learning results		
Professional Competence				
Knowledge	The students will be able to explain the properties of advance	d materials along with	their applications in techn	ology, in particular
	metallic, ceramic, polymeric, semiconductor, modern composit	e materials (biomateri	als) and nanomaterials.	
Skills	The students will be able to select material configurations a	according to the techr	nical needs and, if necessa	ary, to design new
	materials considering architectural principles from the micro	•		,
	modern materials science, which enables them to selec			
	applications.			
Personal Competence	The state of the s	de als aldres 6 disco		
Social Competence	The students are able to present solutions to specialists and to	develop ideas further.		
Autonomy	The students are able to			
	<ul> <li>assess their own strengths and weaknesses.</li> </ul>			
	gather new necessary expertise by their own.			
	, , ,			
Credit points				
Examination				
	30 min			
scale	Materials Colored Control Control			
_		riala, Elastiva Campula	0.07	
Following Curricula	Mechanical Engineering and Management: Specialisation Mater Biomedical Engineering: Specialisation Artificial Organs and Re	•	•	
	Biomedical Engineering: Specialisation Artificial Organs and Re Biomedical Engineering: Specialisation Implants and Endoprost	-		
	Biomedical Engineering: Specialisation Medical Technology and	·	•	
	Biomedical Engineering: Specialisation Management and Busin	•		
	Theoretical Mechanical Engineering: Specialisation Materials So		, ,	

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. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Robert Meißner, Prof. Kaline Pagnan
	Furlan
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.

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Courses				
Title		Тур	Hrs/wk	СР
Introduction to Biochemistry and M		Lecture	2	3
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives		have reached the following learning results		
Professional Competence		nave reactied the following learning results		
	The students can			
Miowicage	The stadenes can			
	<ul> <li>describe basic biomolecules;</li> </ul>			
	explain how genetic information			
	explain the connection between	DNA and proteins;		
Skills	The students can			
	recognize the importance of mole	ecular parameters for the course of a disease;		
	describe selected molecular-diag			
	explain the relevance of these prices.	rocedures for some diseases		
Personal Competence			1	
Social Competence	The students can participate in discussi	ions in research and medicine on a technical lev	eı.	
	Students will have an improved under	rstanding of current medical problems (e.g. Co	orona pandemic)and wil	l be able to expl
	these issues to others.			
Autonomy	The students can develop an understan	nding of topics from the course, using technical l	iterature, by themselves	5.
	Students will be better equipped to reco	ognize fake news in the media regarding medica	al research topics.	
Workload in Hours	Independent Study Time 62, Study Time	e in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German p	program, 7 semester): Specialisation Biomedical	Engineering: Compulso	ry
Following Curricula	General Engineering Science (Germa	n program, 7 semester): Specialisation Mec	hanical Engineering, Fo	ocus Biomechani
	Compulsory			
	3 3 1	edical Technology: Elective Compulsory		
	Engineering Science: Specialisation Bio		Facilitation Control	
		program, 7 semester): Specialisation Biomedical	Engineering: Compulsor	У
	Mechanical Engineering: Specialisation	Management and Business Administration: Elect	tive Compulsory	
	bioinedical Engineering: Specialisation	management and business Administration: Elect	' '	
	Biomedical Engineering: Specialisation	Artificial Organs and Regenerative Medicine: Flo	active Compulsory	
		Artificial Organs and Regenerative Medicine: Ele		
	Biomedical Engineering: Specialisation	Artificial Organs and Regenerative Medicine: Ele Medical Technology and Control Theory: Elective Implants and Endoprostheses: Elective Compuls	e Compulsory	

Course L0386: Introduction t	o 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
<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 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 ar
	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	Lecture
Typ Hrs/wk	
СР	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	WiSe Topics to be covered include:
Content	Introduction (Importance, nomenclature, relations)
	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.

S			
Courses			
Fitle	Тур	Hrs/wk	CP
Structure and Properties of Polymers (L0389) Processing and design with polymers (L1892)	Lecture Lecture	2	3 3
Module Responsible Dr. Hans Wittich	Lecture	2	3
Admission Requirements None			
Recommended Previous Basics: chemistry / physics / ma	itorial science		
Knowledge	iterial science		
	tudents have reached the following learning results		
Professional Competence	tadenie nave redened the ronowing redening research		
	e of plastics and define the necessary testing and analy	rsis.	
They can explain the complex r	elationships structure-property relationship and		
the interactions of chemical striprotection).	ucture of the polymers, including to explain neighboring	contexts (e.g. sustaina	ability, environmenta
Skills Students are capable of			
- using standardized calculation evaluate the different materials	on methods in a given context to mechanical prope	rties (modulus, streng	th) to calculate an
- selecting appropriate solution	s for mechanical recycling problems and sizing example	e stiffness, corrosion re	sistance.
Personal Competence			
Social Competence Students can	Students can		
- arrive at funded work results i	n heterogenius groups and document them.		
ave de landed nom resalles.	cco.oge.mas groups and accament them.		
- provide appropriate feedback	and handle feedback on their own performance constru	ctively.	
Autonomy Students are able to			
- assess their own strengths an	d weaknesses.		
- assess their own state of learn	ing in specific terms and to define further work steps or	n this basis.	
- assess possible consequences	of their professional activity.		
Workload in Hours Independent Study Time 124, S	tudy Time in Lecture 56		
Credit points 6			
Course achievement None			
Examination Written exam			
Examination duration and 180 min			
scale			
Assignment for the Materials Science: Specialisatio	n Engineering Materials: Elective Compulsory		
Following Curricula Biomedical Engineering: Specia	lisation Implants and Endoprostheses: Compulsory		
3 3 1	lisation Artificial Organs and Regenerative Medicine: Ele	' '	
	lisation Management and Business Administration: Elect		
	lisation Medical Technology and Control Theory: Elective		
	s and Production: Specialisation Production: Elective Com		
·	and Production: Specialisation Materials: Elective Com and Production: Specialisation Product Development: E		
·	ring: Specialisation Materials Science: Elective Compuls		

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

Saurana					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (L166	.)	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	pletion of the module stu	dents will be able to describe the basi	ic methods of regeneral	tive medicine and t
,			methods of tissue engineering. They are		
	the cultivation of an	mal and human cells.			
	The students can	utling the actual concen	to of Tissue Engineering and regener	rative modicine and ca	n ovalaja the bas
		of the discussed topics.	ts of Tissue Engineering and regener	ative medicine and ca	in explain the bas
	duncitying principles	or the discussed topics.			
Skills	After successful com	oletion of the module stud	ents are		
	able to use m	dical databases for acquir	ierung and presentation of relevant up-	to-date data independe	ntly
		t their work results in the		to date data macpende.	,
	·		ods and the corresponding analysis inde	ependently	
	able to analys	e and evaluate current res	earch topics for Tissue Engineering and	regenerative medicine.	
Personal Competence					
Social Competence	Students are able to	work together as a team i	with 2-4 students to solve given tasks a	nd discuss their results	in the planary and
Social Competence	defend them.	work together as a team i	vitil 2-4 students to solve given tasks a	nu discuss trieli results	in the pienary and
	defend them.				
	Students are able to	reflect 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 persor
	-	ing a presentation of the r			
Workload in Hours		me 124, Study Time in Le	cture 56		
Credit points		Form	Description		
Course achievement	Yes 20 %	Written elaboration	Description Ausarbeitung zu Ringvorlesung / pr	otocol for lecture series	
Examination					
Examination duration and	Oral presentation +	liscussion (30 min)			
scale	2.a. p. cociliación				
Assignment for the	Biomedical Engineer	ng: Specialisation Implant	s and Endoprostheses: Elective Compul	sory	
Following Curricula	_		l Organs and Regenerative Medicine: Co	•	
•	_	•	ment and Business Administration: Elec		
	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 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			
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			
Educational Objectives	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
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.		
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.		
Personal 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 Biomechanics		
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		
	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 Workland in House		
	Prof. Michael Morlock	
Language		
Cycle	WiSe	
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	Cooking V.B. Othor distance Distriction	
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 M0634: Introduction into Medical Technology and Systems						
Courses						
Title			1	Гур	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)			L	ecture	2	3
Introduction into Medical Technology and Systems (L0343)				Project Seminar	2	2
Introduction into Medical Technolog	I	_	F	Recitation Section (large)	1	1
Module Responsible		efer				
Admission Requirements						
Recommended Previous						
Knowledge	principles of stochastics principles of programming, R/Matlab					
	principles of programm	ming, Nimatiab				
<b>Educational Objectives</b>	After taking part succ	essfully, students have rea	ached the following	g learning results		
Professional Competence						
Knowledge	The students can ex	plain principles of medica	al technology, incl	uding imaging systems,	computer aided s	urgery, and medical
	information systems.	They are able to give an o	verview of regulate	ory affairs and standards	in medical technolo	ogy.
Skills	The students are able	The students are able to evaluate systems and medical devices in the context of clinical applications.				
		,				
Personal Competence						
Social Competence		e a problem in medical tec			-	
	The students can criti	ically reflect on the results	of other groups ar	nd make constructive sug	gestions for improv	ement.
4	The shorteness are	and their lavel of lowers.			h	
Autonomy		sess their level of knowle them in an appropriate m		nt their work results. I	ney can critically	evaluate the results
	acilieved and present	. triem in an appropriate m	idililei.			
Workload in Hours	Independent Study Tir	me 110, Study Time in Led	cture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 % Yes 10 %	Written elaboration				
Examination		Presentation				
Examination duration and	Written exam 90 minutes					
scale	90 minutes					
Assignment for the	General Engineering (	Science (German program,	7 semester): Spec	rialisation Biomedical Eng	ineering: Compulso	nrv
Following Curricula		pecialisation II. Mathematic	•	-		,
3		isation II. Application: Elec		,,,	,	
	Data Science: Core Qualification: Elective Compulsory  Electrical Engineering: Core Qualification: Elective Compulsory					
	Engineering Science:	Specialisation Biomedical	Engineering: Comp	pulsory		
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory					ry
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory  Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
	_				Lompuisory	
	recimomathematics:	Specialisation III. Engineer	ing science: Electi	ve compuisory		

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	Bernhard Priem, "Visual Computing for Medicine", 2014					
	Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097)					
	/alery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015					
	Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014					
	H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687)					
	Wolfgang Drexler, "Optical Coherence Tomography", 2008					
	Kramme, "Medizintechnik", 2011					
	Thorsten M. Buzug, "Computed Tomography", 2008					
	Otmar Scherzer, "Handbook of Mathematical Methods in Imaging", 2015					
	Weishaupt, "Wie funktioniert MRI?", 2014					
	Paul Suetens, "Fundamentals of Medical Imaging", 2009					
	Vorlesungsunterlagen					

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 SoSe			
Content	See interlocking course			
Literature	See interlocking course			

ourse L1876: Introduction into Medical Technology and Systems				
Тур	Recitation Section (large)			
Hrs/wk	1			
СР	1			
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14			
Lecturer	Prof. Alexander Schlaefer			
Language	DE			
Cycle	SoSe SoSe			
Content	See interlocking course			
Literature	See interlocking course			

				,		
Courses						
Title		Тур	Hrs/wk	CP		
Robotics and Navigation in Medicin		Lecture	2	3		
Robotics and Navigation in Medicin		Project Seminar	2 1	2		
Robotics and Navigation in Medicin		Recitation Section (small)		1		
	Prof. Alexander Schlaefer					
Admission Requirements	None					
Recommended Previous	<ul> <li>principles of math (algebra, analys</li> </ul>	sis/calculus)				
Knowledge	<ul> <li>principles of programming, e.g., in</li> </ul>	Java or C++				
	solid R or Matlab skills					
	After taking part successfully, students h	ave reached the following learning results				
Professional Competence						
Knowledge	· ·	d tracking systems in clinical contexts and illu				
	detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typica					
	systems regarding design and limitations.					
Skills	The students are able to design and evalu	uate navigation systems and robotic systems for	medical application	s.		
Personal Competence						
Social Competence	The students are able to grasp practical	I tasks in groups, develop solution strategies in	ndependently, define	work processes ar		
	work on them collaboratively.					
	The students are able to collaboratively organize their work processes and software solutions using virtual communication and					
	software management tools.					
	The students can critically reflect on the results of other groups, make constructive suggestions for improvement, and also					
	incorporate them into their own work.					
Autonomy		knowledge and independently control their lea				
		ritically evaluate the results achieved and prese	ent them in an appro	priate argumentativ		
	manner to the other groups.					
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70				
Credit points						
Course achievement	Compulsory Bonus Form	Description				
	Yes 10 % Written elaboration Yes 10 % Presentation	on .				
Examination						
	Written exam 90 minutes					
Examination duration and scale	30 minutes					
	Computer Science: Specialisation II: Intell	liganca Engineering: Elective Compulsory	<del></del>			
Following Curricula	· ·					
. onowing curricula		ncal rectinology: Elective Compulsory  ng: Specialisation II. Electrical Engineering: Elect	tive Compulsory			
	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Biomedical Engineering: Specialisation Intelligent Systems and Robotics: Elective Compulsory  Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory  Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory					
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory					
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory					
	Product Development, Materials and Production: Specialisation Production: Elective Compulsory					
	Product Development, Materials and Production: Specialisation Materials: Elective Compulsory					
		decioni opecianoación i lacenaisi Elective compe				

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Turn	Hrs/wk	CP
Nonlinear Dynamics (L0702)		<b>Typ</b> Integrated Lecture	4	6
-	Prof. Norbert Hoffmann	egracea zectare	· .	
Admission Requirements	None			
Recommended Previous	None			
Knowledge	Calculus			
Knowieuge	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge				
	Students are able to reflect existing terms and contains are able to reflect existing terms and contains are able to reflect existing terms.	oncepts in Nonlinear Dynamics and	d to develop and rese	earch new terms and
	concepts.			
	<ul> <li>Students are able to denote and expand method.</li> </ul>	s of modeling and analysis for nonl	iinear dynamicai sysi	ems.
Skills	5			
	Students are able to apply existing methods and	•		
	<ul> <li>Students are able to develop novel methods and</li> </ul>	procedures for nonlinear dynamics	ai systems.	
Personal Competence				
Social Competence				
	Students can analyze problems of nonlinear dyna     Chydente and achieve achieve and the property of the			
	Students can achieve solution procedures for pro	iblems of nonlinear dynamical syst	erris also iri groups.	
Autonomy	Charleste and alle to assume the single and assume the		ta atticidado a tido	
	<ul> <li>Students are able to approach given research tasks on the basis of given methods individually.</li> <li>Students are able to identify and follow up novel research tasks by themselves.</li> </ul>			
	Students are able to identify and follow up flover	research tasks 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				
_	Aircraft Systems Engineering: Core Qualification: Elective			
Following Curricula	International Management and Engineering: Specialisat			
	Mechanical Engineering and Management: Specialisation	· ·	ory	
	Mechatronics: Specialisation System Design: Elective Co			
	Mechatronics: Specialisation Intelligent Systems and Ro Biomedical Engineering: Specialisation Artificial Organs		ve Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En	•		
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol  Biomedical Engineering: Specialisation Management an	•		
	Product Development, Materials and Production: Core Q		2 20pui301 y	
	Theoretical Mechanical Engineering: Core Qualification:			

Course L0702: Nonlinear Dynamics		
Тур	egrated 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	
	One dimensional problems Linear Stability Local Bifurcations Synchronisation  Two dimensional problems Limit Cycles Global Bifurcations  Chaos  Lorenz Equations Fractals and Strange Attractors Predictability and Horizons	
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.	

Module MU/61: Semi	conductor Technology			
Courses				
Гitle		Тур	Hrs/wk	СР
Semiconductor Technology (L0722	2)	Lecture	4	4
Semiconductor Technology (L0723		Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	, , , , , , , , , , , , , , , , , , ,	or devices		
Knowledge				
Educational Objectives	* '	ng learning results		
Professional Competence				
Knowledge				
	Students are able			
	to describe and to explain current fabrication techniques for	r Si and GaAs substrates		
	to describe and to explain earrent labilitation teeningues for	Si ana dana sabatiates	,	
	<ul> <li>to discuss in details the relevant fabrication processes semiconductor devices and integrated circuits and</li> </ul>	es, process flows and	the impact thereof on	the fabrication o
	to present integrated process flows.			
CI III.				
Skills				
	Students are capable			
	to analyze the impact of process parameters on the process	sing results		
	to analyze the impact of process parameters on the processing results,			
	to select and to evaluate processes and			
	to develop process flows for the fabrication of semiconductors	or devices.		
Downsonal Commetons				
Personal Competence Social Competence				
Joeial Competence				
	Students are able to plan and carry out experiments in group	·	•	
	These social skills are practiced both during the preparation p			ent the theory, and
	during the follow-up phase, in which the groups prepare, docum	ent and present their pra	actical experiences.	
Autonomy	The independence of the students is demanded and promoted	in that they have to tra-	nsfer and annly what th	nev have learned to
Autonomy	ever new boundary conditions. This requirement is communicate	•		•
	the exam. Students are encouraged to work independently by r			
	step by step by asking specific questions. Students learn to a	sk questions independe	ntly when they are fac	ed with a problem
	They learn to independently break down problems into manages	able sub-problems.		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement				
Examination	Oral exam			
Examination duration and				
scale				
Assignment for the				
Following Curricula				
	Biomedical Engineering: Specialisation Implants and Endoprosth			
	Biomedical Engineering: Specialisation Medical Technology and			
	Biomedical Engineering: Specialisation Management and Busine		ve Compulsory	
	Microelectronics and Microsystems: Core Qualification: Elective	Compulsory		

.0722: Semiconducto	or Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process</li> <li>Wafer fabrication (process flow, specification, SOI)</li> <li>Fabrication processes</li> <li>Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, 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 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 vacual</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, electr 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 etchin backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)</li> <li>Process integration (CMOS process, bipolar process)</li> </ul>
	<ul> <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>
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. Timeringmann. Sinziam Haistetteetinologie, Teasher veriag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	C. Carrahalli. The Cairnes and Favinancian of Missaalashania Fall (1911). O. Call III. 1911. D. Ca
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press

Course L0723: Semiconducto	Course L0723: Semiconductor Technology	
Тур	Practical Course	
Hrs/wk	2	
СР	2	
Workload in Hours	dependent 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	

P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Module M0835: Huma	anoid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	Introduction to control systems			
	Control theory and design			
	Control theory and design			
<b>Educational Objectives</b>	After taking part successfully, students have r	reached the following learning results		
<b>Professional Competence</b>				
Knowledge	Students can explain humanoid robots.			
	Students learn to apply basic control co		hotics	
	Students learn to apply basic control co	meepts for different tasks in namanola ro	boties.	
Skills				
55	<ul> <li>Students acquire knowledge about sele</li> </ul>	ected aspects of humanoid robotics, based	d on specified literature	
	Students generalize developed results:			
	Students practice to prepare and give a	a presentation		
Personal Competence				
Social Competence				
	<ul> <li>Students are capable of developing solutions in interdisciplinary teams and present them</li> <li>They are able to provide appropriate feedback and handle constructive criticism of their own results</li> </ul>			
	Iney are able to provide appropriate te	edback and nandle constructive criticism	of their own results	
Autonomy	Children and design		fifi	
	<ul> <li>Students evaluate advantages and dr solution</li> </ul>	rawbacks or different forms of presenta	tion for specific tasks	and select the bes
	Students familiarize themselves with a	a scientific field are able of introduce it	and follow presentation	ns of other students
	such that a scientific discussion develo		and ronow presentation	is or other students
Workload in Hours		cture 28		
Credit points				
Course achievement				
Examination Examination duration and				
scale	30			
Assignment for the	Mechatronics: Specialisation Intelligent Syster	ms and Robotics: Elective Compulsory		
Following Curricula				
3	Biomedical Engineering: Specialisation Artifici		ective Compulsory	
	Biomedical Engineering: Specialisation Implan			
	Biomedical Engineering: Specialisation Medica	al Technology and Control Theory: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Manag	ement and Business Administration: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: Specialis	ation Robotics and Computer Science: Ele	ective Compulsory	

Course LOCCO Homes sid Bol	hadding.
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	СР
Linear and Nonlinear System Identi	ification (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous				
Knowledge	Classical control (frequency response methods	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			
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the gene	ral framework of the prediction error method a	and its application to a v	variety of linear and
	nonlinear model structures	·		•
	They can explain how multilaye	r perceptron networks are used to model nonline	ear dynamics	
	They can explain how an approx	ximate predictive control scheme can be based o	on neural network model	S
	They can explain the idea of subspace identification and its relation to Kalman realisation theory			
Skills				
Skills	• Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear			
models for dynamic systems				
	They are capable of implementing a nonlinear predictive control scheme based on a neural network model  They are capable of capability who are allowith made to the averaging or to be discontinuously for the second of the			
	<ul> <li>They are capable of applying subspace algorithms to the experimental identification of linear models for dynamic systems</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 Matlab Syste	em identification rootbox	K)
<b>Personal Competence</b>				
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, litera	ature software documer	station) and use it to
natonomy	solve given problems.	mudon in sources provided (rectare notes, intere	atare, sortware accumen	itation, and ase it to
Workload in Hours	Independent Study Time 62, Study Tin	ne in Lecture 28		
Credit points				
Course achievement	None			
Examination				
Examination duration and	30 min			
scale				
_		Control and Power Systems Engineering: Elective	Compulsory	
Following Curricula	,	at Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System D	pesign: Elective Compuisory n Artificial Organs and Regenerative Medicine: Ele	ective Compulsory	
		n Artificial Organs and Regenerative Medicine: Ele n Implants and Endoprostheses: Elective Compuls		
		n Medical Technology and Control Theory: Compu		
		n Management and Business Administration: Elec		
	Theoretical Mechanical Engineering: C		,,	
		· ,		

Course L0660: Linear and No	onlinear 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>

Module M0840: Optin	nal and Robust Control			
Courses				
Courses Title		Typ	Hrs/wk	СР
Title Optimal and Robust Control (L0658	)	<b>Typ</b> Lecture	2	3
Optimal and Robust Control (L0659		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous		In a constant of the constant		
Knowledge	<ul> <li>Classical control (frequency response, root</li> <li>State space methods</li> </ul>	locus)		
	Linear algebra, singular value decomposition	on.		
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	<ul> <li>Students can explain the significance of the</li> </ul>	e matrix Riccati equation for the solution of I	_Q problems.	
	They can explain the duality between opting			
	They can explain how the H2 and H-infinity	norms are used to represent stability and p	erformance const	traints.
	<ul> <li>They can explain how an LQG design problem</li> </ul>	em can be formulated as special case of an	H2 design probler	m.
	They can explain how model uncertainty containing the second	an be represented in a way that lends itself	to robust controll	er design
	They can explain how - based on the sma	ll gain theorem - a robust controller can gu	arantee stability	and performance
	an uncertain plant.			
	<ul> <li>They understand how analysis and synthes</li> </ul>	is conditions on feedback loops can be repre	sented as linear	matrix inequalities
Skills				
	Students are capable of designing and tuni			
	<ul> <li>They are capable of representing a H2 or F software tools for solving it.</li> </ul>	i-infinity design problem in the form of a gel	ieralized plant, a	nd or using standa
	They are capable of translating time and a	frequency domain specifications for control	loons into consti	raints on closed-lo
	sensitivity functions, and of carrying out a		loops lile consti	units on closed-lo
	They are capable of constructing an LFT	, ,	, and of designir	ng a mixed-object
	robust controller.	,	,	,
	They are capable of formulating analysis a	nd synthesis conditions as linear matrix ine	qualities (LMI), a	nd of using standa
	LMI-solvers for solving them.			
	They can carry out all of the above using states.	tandard software tools (Matlab robust contro	l toolbox).	
Personal Competence				
•	Students can work in small groups on specific pro	blems to arrive at joint solutions		
Autonomy	Students are able to find required information in		oftware documer	ntation) and use it
riaconomy	solve given problems.	sources provided (rectare motes) mendiane, s	oremane adeamer	reaction, and about
	g p			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 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 and	Power Systems Engineering: Elective Compu	ulsorv	
Following Curricula	Energy Systems: Core Qualification: Elective Com		,	
_	Aircraft Systems Engineering: Core Qualification:	Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems a	and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elec	tive Compulsory		
	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Elective (	Compulsory	
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Te	echnology and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Manageme			
	Product Development, Materials and Production: 9			
	Product Development, Materials and Production: 9	specialisation Production: Elective Compulso	ry	
	Product Development, Materials and Production: 9	Enocialization Materials: Flasting Communication		

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

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 Marketing)
Courses	
Title	Typ Hrs/wk CP
Marketing of Innovations (L2009)	Lecture 4 4
PBL Marketing of Innovations (L086	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 principles (strategic planning, decision theory, project management,
	international business)
	Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Basics 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	
nnemeage.	state in the game a deep and standing of
	Specific characteristics in the marketing of innovative poroducts and services
	Approaches for analyzing the current market situation and the future market development  The path arise of information of any fiture part for the part of the
	<ul> <li>The gathering of information about future customer needs and requirements</li> <li>Concepts and approaches to integrate lead users and their needs into product and service development processes</li> </ul>
	Approaches and tools for ensuring customer-orientation in the development of new products and innovative services
	Marketing mix elements that take into consideration the specific requirements and challenges of innovative products and
	services
	Pricing methods for new products and services
	The organization of complex sales forces and personal selling
	Communication concepts and instruments for new products and services
Skills	Based on the acquired knowledge students will be able to:
	Design and to evaluate decisions regarding marketing and innovation strategies
	Analyze markets by applying market and technology portfolios
	Conduct forecasts and develop compelling scenarios as a basis for strategic planning
	Translate customer needs into concepts, prototypes and marketable offers and successfully apply advanced methods for
	customer-oriented product and service development
	Use adequate methods to foster efficient diffusion of innovative products and services
	Choose suitable pricing strategies and communication activities for innovations
	<ul> <li>Make strategic sales decisions for products and services (i.e. selection of sales channels)</li> <li>Apply methods of sales force management (i.e. customer value analysis)</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
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	
Credit points	
Course achievement	
Examination	
Examination duration and	Written elaboration, excercises, presentation, oral participation
Scale	Global Technology and Innovation Management & Entrepreneurship Core Qualification, Fleeting Computers
Assignment for the Following Curricula	
. Onowing 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 Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Compulsory

Course L2009: Marketing of	Innovations	
Тур	Lecture	
Hrs/wk	4	
СР	4	
	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 Marketin	Course L0862: PBL Marketing of Innovations	
Тур	Project-/problem-based Learning	
Hrs/wk	1	
СР	2	
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14	
Lecturer	Prof. Christian Lüthje	
Language	EN	
Cycle	SoSe	
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1) forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation, managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making within a market simulation game.	
Literature		

Module M0938: Biopr	ocess Engineering - Fundamentals	3		
•				
Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering - Fundamer Bioprocess Engineering - Fundame		Recitation Section (large) Practical Course	2	1 2
		Fractical Course	2	2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	module "organic chemistry", module "fundamenta	ils for process engineering"		
	After taking part successfully, students have reacl	and the following learning results		
-	After taking part successibility, students have reach	led the following learning results		
Professional Competence	Students are able to describe the basis consents	of higher costs and incoring. They are able to	classify different	tunes of kinetics for
Knowieage	Students are able to describe the basic concepts			
	enzymes and microorganisms, as well as to di			
	rheology can be named and mass transport pro			e capable to explain
	fundamental bioprocess management, sterilization	recimology and downstream processing in	i detaii.	
Skills	After successful completion of this module, studer	nts should be able to		
	<ul> <li>describe different kinetic approaches for gr</li> </ul>	owth and substrate-uptake and to calculate	the correspondir	g parameters
	<ul> <li>predict qualitatively the influence of ener fermentation process</li> </ul>	gy generation, regeneration of redox equi	valents and grov	vth inhibition on the
	analyze bioprocesses on basis of stoichiometers	etry and to set up / solve metabolic flux equ	ıations	
	distinguish between scale-up criteria for dif	ferent bioreactors and bioprocesses (anaer	obic, aerobic as v	vell as microaerobic)
	to compare them as well as to apply them t	o current biotechnical problem		
	<ul> <li>propose solutions to complicated biotechnome</li> </ul>	logical problems and to deduce the corresp	onding models	
	to explore new knowledge resources and to			
	identify scientific problems with concrete in			
	to document and discuss their procedures a	as well as results in a scientific manner		
Personal Competence				
Social Competence	After completion of this module participants shou			
	take position to their own opinions and increase th	neir capacity for teamwork in engineering a	nd scientific envi	onments.
Autonomy	After completion of this module participants will be	pe able to solve a technical problem in a te	am independentl	v by organizing their
	workflow and to present their results in a plenum			, .,
Workload in Hours	Independent Study Time 96, Study Time in Lecture	e 84		
Credit points	6			
Course achievement		Description		
	Yes 5 % Subject theoretical an	a		
	practical work			
	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Bioprocess Engineering: Core Qualification: Comp	ulsory		
Following Curricula	Green Technologies: Energy, Water, Climate: Spec	cialisation Bioresource Technology: Elective	Compulsory	
-	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Compulso	ory	
	Biomedical Engineering: Specialisation Implants a			
	Biomedical Engineering: Specialisation Medical Te	chnology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Manageme	ent and Business Administration: Elective Co	mpulsory	
	Technomathematics: Specialisation III. Engineering	g Science: Elective Compulsory		
	Process Engineering: Core Qualification: Compulso	pry		

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	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
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out.  The students document their experiments and results in a protocol.
Literature	Skript

Module M1143: Applied Design Methodology in Mechatronics				
Courses				
Title		Тур	Hrs/wk	СР
Applied Design Methodology in Med		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 compu	ter-sciences		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	ne following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product des	gn considering targeted application of spe	ecific product	design techniques
Skills	Creative handling of processes used for scientific prepa	ration and formulation of complex produc	t design prob	olems / Application of
	various product design techniques following theoretical	aspects.		
Personal Competence				
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 development	opment process according to the target ar	nd topic of the	e design
	Students are educated to operate in a development tea	m		
	Students learn about the right application of creative m	ethods in engineering.		
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: Specialisat	ion II. Product Development and Production	on: Elective C	ompulsory
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation	n Product Development and Production: E	lective Comp	oulsory
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and En	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation Proc	uct Development 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	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		

Module M1280: MED I	II: Introduction to Physiology				
Courses					
Title	Typ Hrs/wk CP				
Introduction to Physiology (L0385)	Lecture 2 3				
Module Responsible	Dr. Roger Zimmermann				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part successfully, students have reached the following learning results				
<b>Professional Competence</b>					
Knowledge	The students can				
	describe the basics of the energy metabolism;				
	describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.				
G					
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, developmen				
Davisanal Compatones	of forces and vital functions) and relate them to similar technical systems.				
Personal Competence	The students can conduct discussions in research and medicine on a technical level.				
Social Competence	The students can find solutions to problems in the field of physiology, both analytical and metrological.				
	The state has call this solutions to prosterior in the head of physiology, sour analysical and metalogical				
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by				
	themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and	60 minutes				
scale					
•					
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics				
	Compulsory  Data Sciences Specialization Medicines Compulsors				
	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 Biomedical Engineering: Elective Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory				

Course L0385: Introduction t	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	l: Introduction to Anatomy			
Courses				
Title	Typ Hrs/wk CP			
ntroduction to Anatomy (L0384)	Lecture 2 3			
Module Responsible	Prof. Udo Schumacher			
Admission Requirements	None			
Recommended Previous	Students can listen to the lectures without any prior knowledge. Basic school knowledge of biology, chemistry / biochemis			
Knowledge	physics and Latin can be useful.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
	The lectures are about microscopic anatomy, describing the microscopic structure of tissues and organs, and about macroscop anatomy which is about organs and organ systems. The lectures also contain an introduction to cell biology, human development and to the central nervous system. The fundamentals of radiologic imaging are described as well, using projectional x-ray are cross-sectional images. The Latin terms are introduced.  At the end of the lecture series the students are able to describe the microscopic as well as the macroscopic assembly are functions of the human body. The Latin terms are the prerequisite to understand medical literature. This knowledge is needed to			
	understand und further develop medical devices.  These insights in human anatomy are the fundamentals to explain the role of structure and function for the developm common diseases and their impact on the human body.			
Personal Competence				
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level. The Latin to are prerequisite for communication with physicians on a professional level.			
Autonomy	The lectures are an introduction to the basics of anatomy and should encourage students to improve their knowledge themselves. Advice is given as to which further literature is suitable for this purpose. Likewise, the lecture series encourastudents to recognize and think critically about biomedical problems.			
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			
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechan			
	Compulsory			
	Data Science: Specialisation II. Application: Elective 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 L0384: Introduction t	to Anatomy			
	Lecture			
Hrs/wk	2	2		
СР				
Workload in Hours		ndependent Study Time 62, Study Time in Lecture 28		
	_	Prof. Tobias Lange		
Language				
Cycle	General Anatomy			
Content	1 <sup>st</sup> week:	The Eucaryote Cell		
	2 <sup>nd</sup> week: 3 <sup>rd</sup> week:	The Tissues  Cell Cycle, Basics in Development		
	4 <sup>th</sup> week:	Musculoskeletal System		
	5 <sup>th</sup> week: 6 <sup>th</sup> week:	Cardiovascular System  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/Michae	l Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016		

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	Monthly and a second Health to be a second of the feet of the second of				
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 anatomy, pathology and pathophysiology.				
Personal Competence					
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way.  The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.				
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.				
	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics Compulsory				
	Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory				
	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  DF
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					
Admission Requirements	None					
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is re	ecommended.				
Knowledge						
<b>Educational Objectives</b>	After taking part successfully, students have reached the fo	ollowing learning results				
<b>Professional Competence</b>						
Knowledge	The students can name the different kinds of artificial limbs	5.				
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.					
Autonomy	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.	They can also judge the	illiormation 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	and Biotechnology: Elective (	Compulsory		
Following Curricula	Materials Science: Specialisation Nano and Hybrid Materials	s: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and	Regenerative Medicine	: Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and Endop	rostheses: Compulsory				
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elec	ctive Compulsory			
	Biomedical Engineering: Specialisation Management and B		Elective Compulsory			
	Orientation Studies: Core Qualification: Elective Compulsor	•				
	Theoretical Mechanical Engineering: Specialisation Bio- and	l Medical Technology: Ele	ective Compulsory			

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

Module M0845: Feedl	oack Control in Medical Tech	inology			
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 h	ave reached the following learning results			
<b>Professional Competence</b>					
Knowledge	The lecture will introduce into the fasci human physiology will be similarly introd	nating area of medical technology with the enuced like knowledge in control theory.	gineering point of vie	w. Fundamentals in	
	Internal control loops of the human boo example in for anesthesia control.	dy will be discussed in the same way like the	design of external clo	osed loop system fo	
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.				
Skills	Application of modeling, identification, co	ontrol technology in the field of medical technolo	gy.		
Personal Competence Social Competence	Students can develop solutions to specifi	c problems in small groups and present their res	ults		
Autonomy	, and the second	ature 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	in Lecture 28			
Credit points	3				
Course achievement	None				
Examination	Oral exam				
Examination duration and	20 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Med	dical Technology: Elective Compulsory			
Following Curricula	Electrical Engineering: Specialisation Cor	ntrol and Power Systems Engineering: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsor	У		
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elect	ive Compulsory		
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Electiv	e Compulsory		
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Compulse	ory		

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

Courses				
Гitle		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			
<b>Recommended Previous</b>	none			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge	After successfully participating in the module case stu	dies on regenerative medicine	and tissue engineering, th	ne students
	<ul> <li>can recognize, how a team works together to w</li> </ul>	ork on a complex task		
	<ul> <li>can assign, which planning tools are required f</li> </ul>	or new cell-based therapy conc	epts and medical product	s from the "proof-
	concept" to successful market approval			
	<ul> <li>can illustrate, which obstacles and difficulties a</li> </ul>	rise during the market approval	of the concepts and prod	ducts mentioned
Skills	After successful completion of the module students are  • able to use relevant 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 analyse and evaluate current research to	opics and applications for Tissu	e Engineering and Regen	erative Medicine.
Personal Competence				
Social Competence	Students are able to work together as a team with 6-8 students to solve given tasks and discuss their results in the plenary and to			
	defend them.			
	Students are able to reflect their work orally and discu	iss it with other students and te	achers.	
Autonomy	After completion of this module, participants will	be able to solve a technical	problem in teams of a	approx. 6-8 perso
	independently			
	including a presentation of the results.			
Workload in Hours	Independent Study Time 138, Study Time in Lecture 4	2		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: C	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	ndoprostheses: Elective Compu	Isory	
	Biomedical Engineering: Specialisation Management a	nd Business Administration: Ele	ctive Compulsory	
	Biomedical Engineering: Specialisation Medical Techn	plogy and Control Theory: Electi	ve Compulsory	

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	The students should work in working groups to develop concepts for the path from "proof of concept" to successful market approval for new cell-based therapy concepts and medical products. It is assumed that an initial test phase was successful for the respective concepts. A routine clinical application must now be established in each case. Strategies are to be developed for this.
Literature	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540

Courses				
Гitle		Тур	Hrs/wk	СР
Advanced Topics in Control (L0661		Lecture	2	3
Advanced Topics in Control (L0662		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linea	r matrix inequalities		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge Skills	<ul> <li>Students can explain the advantages and shortco</li> <li>They can explain the representation of nonlinear</li> <li>They can explain how stability and performance of they can explain how gridding techniques can be</li> <li>They are familiar with polytopic and LFT representation associated with each of these model structures</li> <li>Students can explain how graph theoretic consistency</li> <li>They can explain the convergence properties of five they can explain analysis and synthesis condition</li> <li>Students can explain concepts behind linear and</li> <li>Students can construct LPV models of nonline controllers; they can do this using polytopic, LFT of they can use standard software tools (Matlab rob)</li> <li>Students can design distributed formation controllers provided</li> </ul>	systems in the form of quasi-LPV systems on the form of quasi-LPV system can be form used to solve analysis and synthesis sentations of LPV systems and some septs are used to represent the coarst order consensus protocols for formation control loops involving the productive Control (MPC) are plants and carry out a mixed-or general LPV models sust control toolbox) for these tasks	ems nulated as LMI co problems for LPV e of the basic s mmunication top g either LTI or LPV sensitivity design	systems synthesis technique ology of multiag / agent models n of gain-schedu
Personal Competence Social Competence Autonomy	<ul> <li>Students can design MPC controllers for linear and Students can work in small groups and arrive at joint res Students can find required information in sources provigiven problems.</li> </ul>	ults.		a) and use it to so
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale	33			
Assignment for the	Electrical Engineering: Specialisation Control and Power		ulsory	
Following Curricula	Aircraft Systems Engineering: Core Qualification: Electiv	, ,		
	International Management and Engineering: Specialisati	·	ory	
	Mechatronics: Specialisation System Design: Elective Co	• •		
	Mechatronics: Specialisation Intelligent Systems and Rol			
	Biomedical Engineering: Specialisation Implants and Engineering			
	Biomedical Engineering: Specialisation Medical Technology		-	
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artificial Organs	and Degenerative Medicine. Flority	Communica	

Course L0661: Advanced Topics in Control					
Тур	Lecture				
Hrs/wk	2				
СР					
Workload in Hours	ndent 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	ependent Study Time 62, Study Time in Lecture 28		
Lecturer	Herbert Werner		
Language	EN		
Cycle	WiSe		
Content	ee interlocking course		
Literature	See interlocking course		

	ectromagnetics: Principles a				
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					
Recommended Previous Knowledge	Basic principles of physics				
<b>Educational Objectives</b>	After taking part successfully, students h	have reached the following	g 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	issue. They can define and frequency of the fields.	d exemplify the most impo They can give an overvic tical applications . They ca	ortant physical ph w over measure	nenomena and orde
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the mo important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength ar frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for the predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make appropriate choice.				
Personal Competence Social Competence	Students are able to work together on s English (e.g. during small group exercise	•	mall groups. They are able	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 betw agnetic fields, fundament	een their knowledge obtain	ned in this lecture	with the content o
Workload in Hours	Independent Study Time 110, Study Tim	ne 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 Mid	crowave Engineering, Opti	ics, and Electromagnetic Co	mpatibility: Electi	ve Compulsory
Following Curricula				. , , , , , , , , , , , , , , , , , , ,	,,
-	International Management and Engineer	ing: Specialisation II. Elect	trical Engineering: Elective	Compulsory	
	Biomedical Engineering: Specialisation M	Management and Business	Administration: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprosthes	ses: Elective Compulsory		
	Biomedical Engineering: Specialisation A	Artificial Organs and Reger	nerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation N	Medical Technology and Co	ontrol Theory: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Spe	ecialisation Bio- and Medic	al Technology: Elective Cor	npulsory	

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)			
	1			

Course L0373: Bioelectroma	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		

## **Specialization Artificial Organs and Regenerative Medicine**

Module M0623: Intell	igent Systems	in Medicine				
Courses						
Title				Тур	Hrs/wk	CP
Intelligent Systems in Medicine (L0				Lecture	2	3
Intelligent Systems in Medicine (L0				Project Seminar	2	2
Intelligent Systems in Medicine (L0				Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous	• principles of m	nath (algebra, analysis/cal	leulus)			
Knowledge	principles of st		iculus)			
		rogramming, Java/C++ ar	nd R/Matlah			
	advanced proc		ia iyinadab			
	advanced prog	, a				
<b>Educational Objectives</b>	After taking part succ	cessfully, students have re	eached the followi	ng learning results		
<b>Professional Competence</b>						
Knowledge	The students are abl	e to analyze and solve cl	linical treatment p	lanning and decision suppor	rt problems using	methods for search,
	optimization, and pla	nning. They are able to e	xplain methods fo	r classification and their resp	pective advantage:	s and disadvantages
	in clinical contexts. T	he students can compare	different method	ls for representing medical k	nowledge. They ca	n evaluate methods
	in the context of clin	ical data and explain cha	allenges due to th	e clinical nature of the data	and its acquisition	and due to privacy
	and safety requireme	ents.				
Chille	The students can six	o reasons for colocting a	and adapting moth	ods for classification, regres	cion and prodicti	on They can access
Skilis	_	n actual patient data and		-	ssion, and predicti	on. They can assess
	the methods based o	iii actuai patient uata anu	evaluate the imp	emented methods.		
Personal Competence						
Social Competence	The students are ab	le to grasp practical task	s in groups, deve	lop solution strategies indep	pendently, define	work processes and
	work on them collabo	oratively.				
	The students can cr	ritically reflect on the re	sults of other gr	oups, make constructive su	ggestions for imp	provement and also
	incorporate them into	their own work.				
Autonomy	The students can ass	ess their level of knowled	lge and document	their work results. They can	critically evaluate	the results achieved
	and present them in	an appropriate argument	ative manner to th	e other groups.		
Workload in Hours	Independent Study T	ime 110, Study Time in Le	ecture 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	Computer Science: S	pecialisation II: Intelligend	ce Engineering: Ele	ective Compulsory		
Following Curricula	Electrical Engineering	g: Specialisation Medical 1	Γechnology: Electi	ve Compulsory		
	Interdisciplinary Math	nematics: Specialisation C	Computational Met	hods in Biomedical Imaging:	Compulsory	
	Mechatronics: Specia	lisation Intelligent Systen	ns and Robotics: E	lective Compulsory		
	Biomedical Engineeri	ng: Specialisation Artificia	al Organs and Reg	enerative Medicine: Elective	Compulsory	
	Biomedical Engineeri	ng: Specialisation Implan	ts and Endoprosth	eses: Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation Medica	l Technology and	Control Theory: Elective Com	npulsory	
	Biomedical Engineeri	ng: Specialisation Manage	ement and Busine	ss Administration: Elective C	ompulsory	
	Theoretical Mechanic	al Engineering: Specialisa	ation Bio- and Med	ical Technology: Elective Cor	mpulsory	

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

Course L0333: Intelligent Sy	ourse 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 M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)			
Courses					
Title		Тур	Hrs/wk	СР	
Nature's Hierarchical Materials (L16	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 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	2	
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	
Module Responsible	Prof. Michael Morlock				
<b>Admission Requirements</b>	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	12				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory			
_	Biomedical Engineering: Specialisation Medical Techn		pulsory		
Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory					

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

Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well at Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.  Topics:  - Fundamental properties and phenomena of electrical circuits  - Steady-state sinusoidal analysis of electrical circuits  - Fundamental properties and phenomena of electromagnetic fields and waves  - Steady-state sinusoidal description of electromagnetic fields and waves  - Useful microwave network parameters  - Transmission lines and basic results from transmission line theory  - Plane wave propagation, superposition, reflection and refraction  - General theory of waveguides  - Most important types of waveguides and their properties  - Radiation and basic antenna parameters  - Most important types of antennas and their properties  - Numerical techniques and CAD tools for waveguide and antenna design  - Fundamentals of Electromagnetic Compatibility  - Coupling mechanisms and countermeasures  - Shielding, grounding, filtering  - Standards and regulations  - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
Literature	- Zilike, Druhswig, Trochhequeriztechilik I., 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	
	Prof. Michael Morlock
Language	DE
Cycle	SoSe
	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical knowledge is provided.  1. Tribology 2. Optical Methods 3. Motion Analysis 4. Pressure Distribution 5. Strain Gauges 6. Pre-clinical testing 7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen  White A.A., Panjabi M.M.: Clinical biomechanics of the spine  Nigg, B.: Biomechanics of the musculo-skeletal system  Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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 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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

urse L0001: Fluid Mechan	
Тур	
Hrs/wk	
СР	
Workload in Hours	
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, Heidelbei
	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 Strömung
	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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	<ul> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Hydraulic systems and heat transfer</li> <li>Example: System with different subsystems</li> </ul>
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1230: Selec	ted Topics of Biomedical Engineering	g - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	563)	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	nics (L0377)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	2
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
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	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	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
•	Biomedical Engineering: Specialisation Management	• • • • • • • • • • • • • • • • • • • •		
	Biomedical Engineering: Specialisation Artificial Organ		. ,	
	biomedical Engineering. Specialisation Artificial Organ	is and regenerative Medicine. Elective	Compuisory	

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	
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 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
Libountone	- 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	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	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical
	knowledge is provided.
	1. Tribology
	2. Optical Methods
	3. Motion Analysis
	4. Pressure Distribution
	5. Strain Gauges
	6. Pre-clinical testing
	7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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
<b>Examination Form</b>	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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Tim	Lecture	
Тур		
Hrs/wk		
CP		
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	
	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		
Encluture	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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	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 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	d 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	reached the following learning results		
<b>Professional Competence</b>				
	(goals, utilities, environments). They can descan be discussed in terms of decision proble world scenarios, students can summarize hot formalism in static and dynamic settings. In settings, with and with complete access to solving (partially observable) Markov decisio Students can identify techniques for simulta desired states. Students can explain coordinate of equilibria, social choice functions, voting problems can select an appropriate agent are students can derive decision trees and apply networks/dynamic Bayesian networks and different sampling techniques for simplified a best action or policies for concrete settings.	define intelligence in terms of rational behavior cribe the main features of environments. The needs 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 eneous localization and mapping, and can exploration problems and decision making in a multi-arotocol, and mechanism design techniques.  The control of the environment of the environment of the environment of the environment. In this context, on problems, and they can recall techniques for eneous localization and mapping, and can exploration problems and decision making in a multi-arotocol, and mechanism design techniques.  The control of the environment o	otion of adversari.  For dealing with owledge represent procedures in sistudents can desir measuring the value pent setting in telephone pent settin	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	
Autonomy	Ctudents are able of shocking their understar	nding of complex concepts by solving varaints of	concrete problem	05
Autonomy	Students are able of thething their understar	iding of complex concepts by solving varants of	concrete problem	115
Workload in Hours	Independent Study Time 124, Study Time in L	Lecture 56		
Credit points	6			
	None			
Course achievement				
	Written exam			
Examination	90 minutes			
Examination Examination duration and	90 minutes	nce Engineering: Elective Compulsory		
Examination Examination duration and scale	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S	Specialisation II. Information Technology: Electiv	e Compulsory	
Examination Examination duration and scale Assignment for the	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Cou	Specialisation II. Information Technology: Electivrse: Elective Compulsory	e Compulsory	
Examination Examination duration and scale Assignment for the	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: S Mechatronics: Technical Complementary Could Mechatronics: Specialisation Intelligent Systems	Specialisation II. Information Technology: Electiv rse: Elective Compulsory ms and Robotics: Elective Compulsory		
Examination Examination duration and scale Assignment for the	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: SMechatronics: Technical Complementary Coul Mechatronics: Specialisation Intelligent Systel Biomedical Engineering: Specialisation Artificial	Specialisation II. Information Technology: Electiv rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective		
Examination Examination duration and scale Assignment for the	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: SMechatronics: Technical Complementary Coul Mechatronics: Specialisation Intelligent Systel Biomedical Engineering: Specialisation Implantation Implantation Implantation Implantation	Specialisation II. Information Technology: Electives: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective that and Endoprostheses: Elective Compulsory	Compulsory	
Examination Examination duration and scale Assignment for the	90 minutes  Computer Science: Specialisation II: Intelligen International Management and Engineering: SMechatronics: Technical Complementary Coul Mechatronics: Specialisation Intelligent Systel Biomedical Engineering: Specialisation Artifici Biomedical Engineering: Specialisation Implar Biomedical Engineering: Specialisation Medical	Specialisation II. Information Technology: Electiv rse: Elective Compulsory ms and Robotics: Elective Compulsory ial Organs and Regenerative Medicine: Elective	Compulsory	

Course L0341: Intelligent Au	tonomous Agents and Cognitive Robotics	
Тур		
Hrs/wk	2	
СР	4	
	Independent Study Time 92, Study Time in Lecture 28	
	Rainer Marrone	
Language		
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	
	<ul> <li>Bayesian networks:</li> <li>Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case</li> </ul>	
	complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly	
	perceived).	
	Probabilistic reasoning over time:	
	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	
	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	
	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	

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	ation Theory		
Courses			
Title Vibration Theory (L0701)	<b>Typ</b> Integrated Lecture	Hrs/wk	<b>CP</b> 6
Module Responsible	e Prof. Norbert Hoffmann		
Admission Requirements	s None		
Recommended Previous Knowledge	Calculus		
Educational Objectives	s After taking part successfully, students have reached the following learning results		
Professional Competence  Knowledge  Skills	Students are able to denote terms and concepts of Vibration Theory and develop them for Students know methods of modeling and simulation for free, driven, self-excited and pare Students know about concepts of linear and nonlinear vibration problems.     Students know basic tasks of vibration problems of discrete and continuous systems.		ibrations.
Skins	<ul> <li>Students are able to denote methods of Vibration Theory and develop them further.</li> <li>Students are able to apply and expand methods of modeling and simulation for free, driven vibrations.</li> <li>Students are able to solve linear and nonlinear vibration problems.</li> </ul>	forced, self-exc	ited and parameter
Personal Competence Social Competence Autonomy	<ul> <li>Students can analyze vibration problems, work on them, and reach working results also</li> <li>Students are able to document the results of vibration studies also in groups.</li> </ul>	in teams or grou	ps.
Workload in Hours	s Independent Study Time 124, Study Time in Lecture 56		
Credit points			
Course achievement			
Examination duration and	2 Hours		
scale	е		
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory		
Following Curricula	a International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Core Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsionedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory	ompulsory	

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 Vibrations
	<ul> <li>Free vibration</li> <li>Self-excited vibration</li> <li>Parameter driven vibration</li> <li>Forced vibration</li> <li>Multi degree of freedom vibration</li> <li>Continuum vibration</li> <li>Irregular vibration</li> </ul>
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen.  English - K. Magnus: Vibrations.

ourses				
tle		Тур	Hrs/wk	СР
chnology Management (L0849) chnology Management Seminar	10850)	Lecture Project-/problem-based Learning	3	3 3
Module Responsible	Prof. Cornelius Herstatt	Troject-/problem-based Learning	2	3
	None			
Admission Requirements  Recommended Previous	Bachelor knowledge in business management			
Knowledge	bachelor knowledge in business management			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence	The taking pare succession, scaueries have reached the	Tono Imag rearring results		
	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies			
	Technology Strategies and Lifecycle Manage	ement (I/II)		
	Technology Intelligence and Planning			
	Technology Portfolio Management  Technology Portfolio Managem			
	Technology Portfolio Methodology			
	Technology Acquisition and Exploitation			
	IP Management			
	Organizing Technology Development     Tashpalagy Organization & Management			
	Technology Organization & Management     Technology Funding & Controlling			
	Technology Funding & Controlling			
Skills	The course aims to:			
	Develop an understanding of the importance of Territory	chnology Management - on a national a	s well as interr	national level
	<ul> <li>Equip students with an understanding of imp</li> </ul>	ortant elements of Technology Man	agement (str	ategic, operatio
	organizational and process-related aspects)			
	<ul> <li>Foster a strategic orientation to problem-solving v</li> </ul>	vithin the innovation process as well as	Technology N	lanagement and
	importance for corporate strategy			
	<ul> <li>Clarify activities of Technology Management (e.g. t</li> </ul>			
	<ul> <li>Strengthen essential communication skills and a</li> </ul>	basic understanding of managerial, o	rganizational	and financial iss
	concerning Technology-, Innovation- and R&D-man	agement. Further topics to be discussed	d include:	
	Basic concepts, models and tools, relevant to the r	nanagement of technology. R&D and in	novation	
	Innovation as a process (steps, activities and result	•		
Personal Competence				
Social Competence				
	Interact within a team			
	Raise awareness for globabl issues			
Autonomy				
,	<ul> <li>Gain access to knowledge sources</li> </ul>			
	<ul> <li>Discuss recent research debates in the context of</li> </ul>	Technology and Innovation Managemen	t	
	Develop presentation skills			
	Discussion of international cases in R&D-Managem	ent		
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	50 minutes			
	Global Innovation Management: Core Qualification: Comp	ulsony		
Assignment for the	Global Innovation Management: Core Qualification: Comp	*	onulcon.	
Following Curricula	International Management and Engineering: Specialisatio Mechanical Engineering and Management: Specialisation		iipuisoi y	
	Biomedical Engineering: Specialisation Artificial Organs a		nulson/	
	Biomedical Engineering: Specialisation Artificial Organs a Biomedical Engineering: Specialisation Implants and Endo	•	ipuisoi y	
	pioniculcal Engineening. Specialisation implants and Engl	prostrieses. Liettive Cullipuisury		
	Biomedical Engineering: Specialisation Medical Technology	y and Control Theory: Flective Computer	orv	

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.

Module M0846: Contr	rol Systems Theory and Design			
Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Design		Lecture	2	4
Control Systems Theory and Design		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements	Introduction to Control Systems			
Knowledge	included of the control systems			
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	Students can explain how linear dynamic	sustants are represented as state space.	madalar thay san	interpret the system
Skills	response to initial states or external excitai  They can explain the system properties constitution, respectively  They can explain the significance of a mininer they can explain observer-based state feed. They can extend all of the above to multi-iner they can explain the z-transform and its resultance. They can explain state space models and to they can explain the experimental identification be solved by solving a normal equation.  They can explain how a state space model.  Students can transform transfer function means they can assess controllability and observed. They can design LQG controllers for multivation and they can carry out a controller design both for a given sampling rate.  They can identify transfer function models.  They can carry out all these tasks using the significance of a mining transfer function models.	mal realisation dback and how it can be used to achieve trapput multi-output systems lationship with the Laplace Transform ransfer function models of discrete-time systation of ARX models of dynamic systems, can be constructed from a discrete-time in models into state space models and vice very distillity and construct minimal realisations ariable plants h in continuous-time and discrete-time do	stems and how the ident npulse response rsa main, and decide	pance rejection  dification problem can  which is appropriate
	Simulink)  Students can work in small groups on specific pro Students can obtain information from provided swhen solving given problems.  They can assess their knowledge in weekly on-line	sources (lecture notes, software documer	·	nt guides) and use it
Washing dis Harre	ladarandark Chada Tiran 124 Chada Tiran in Lada	F.C		
Credit points	Independent Study Time 124, Study Time in Lectu	iic JU		
·				
Course achievement	Written exam			
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Core Qualification: Compul	sory		
Following Curricula	Energy Systems: Core Qualification: Elective Com	pulsory		
	Aircraft Systems Engineering: Core Qualification:	Elective Compulsory		
	Computer Science in Engineering: Specialisation I		-	
	International Management and Engineering: Spec			
	International Management and Engineering: Spec Mechanical Engineering and Management: Specia	·	•	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial O	rgans and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants a	•	•	
	Biomedical Engineering: Specialisation Medical Te			
	Biomedical Engineering: Specialisation Manageme		Compulsory	
	Product Development, Materials and Production: (			
	Theoretical Mechanical Engineering: Core Qualific	аноп. соптривогу		

7	Lecture	
	Lecture	
Hrs/wk		
СР		
	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	
	sed-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	Warran II. Lashur Nahar Cashad Cushana Thasas and Daring!!	
	Werner, H., Lecture Notes "Control Systems Theory and Design"  T. K. H. H. William S. S. A. and H. Dan H. H. 1900.  T. K. H. H. H. H. L. A. A. A. A. A. H. Dan H. Dan H. H. 1900.  T. K. H. H. H. H. L. A. A. A. A. A. H. Dan H. Dan H. H. 1900.  T. K. H. H. H. H. L. A. A. A. A. A. H. Dan H. Dan H. H. 1900.  T. K. H. H. H. L. A. A. A. A. A. A. H. Dan H. Dan H. H. 1900.  T. K. H. H. H. L. A.	
	T. Kailath "Linear Systems", Prentice Hall, 1980  K. A. Land D. M. Warden L. W. Grand L. G. Charles L. G. Cha	
	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 an	d Digital Enterprise		
ourses				
litle little		Тур	Hrs/wk	СР
he Digital Enterprise (L0932)		Lecture	2	2
roduction Planning and Control (L	0929)	Lecture	2	2
Production Planning and Control (L	0930)	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 I	Management		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and app	plying models and methods from the module to indu	strial problems.	
Personal Competence				
Social Competence	Students can develop joint solutions in m	ixed 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 Engineeri	ng: Specialisation II. Product Development and Produ	uction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spe	ecialisation Production and Logistics: Elective Compu	llsory	
	Biomedical Engineering: Specialisation Ar	rtificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Compulsor	ту	
	Product Development, Materials and Prod	duction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Prod	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Prod	duction: 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. Robert Rost
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 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. Robert Rost	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses				
<b>Title</b> Continuum Mechanics (L1533)		Typ Lecture	Hrs/wk 2	<b>CP</b> 3
Continuum Mechanics Exercise (L1	1.534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	·			
	Basics of mechanics as taught, e.g., in the modules Engineering	g Mechanics I and Engineeri	ng Mechanics II a	at TUHH (forces ar
Knowledge				
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following	ng learning results		
<b>Professional Competence</b>				
Knowledge	In this module, students learn the fundamental concepts of n	onlinear continuum mechan	ics. This theory	enables students
	describe arbitrary deformations of continuous bodies (solid, liqui			
	of the basic module Engineering Mechanics II (elastostatics), the		opic, linear-elasti	c material behavio
	small deformations, simple geometries) of which are successively	/ eliminated.		
	First, the students learn the necessary fundamentals of tensor ca	Iculus. Based on this, the de	scription of the d	eformations / strain
	of arbitrarily deformable bodies is dealt with. The students learn			-
	a body and for formulating the balance equations for mass, mo			
	students know which constitutive assumptions have to be made to	for modeling the material bel	navior of a mecha	inical body.
Skills	The students can set up balance laws and apply basics of defor	rmation theory to specific as	pects, both in ap	plied contexts as
	research contexts.			
Personal Competence				
Social Competence				
	form and to develop ideas further.			
Autonomy	The students are able to assess their own strengths and weakne	sses. They can independentl	y and on their ov	n identify and solv
	problems in the area of continuum mechanics and acquire the kn	lowledge required to this end	l.	
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 Compulsory			
Following Curricula				
	Mechatronics: Technical Complementary Course: Elective Compu		S	
	Biomedical Engineering: Specialisation Artificial Organs and Rege		compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthe Biomedical Engineering: Specialisation Medical Technology and C		nulsory	
	Biomedical Engineering: Specialisation Medical Technology and C Biomedical Engineering: Specialisation Management and Busines		-	
	Product Development, Materials and Production: Core Qualification			
	Theoretical Mechanical Engineering: Core Qualification: Elective (			
		• •		

Course L1533: Continuum Me	echanics
	Lecture
Hrs/wk	
	3
	Independent Study Time 62, Study Time in Lecture 28
	Prof. Christian Cyron
Language	
-	
Content	Continuum mechanics is a general theory to describe the effect of mechanical forces on continuous mechanical (both solid and fluid) bodies. An important part of continuum mechanics is the mathematical description of strains and stresses as well as the stress-strain response of continuous mechanical bodies. The lecture continuum mechanics builds on the foundations tought in the lecture Engineering Mechanics II (Elasotstatics) but extends them significantly, while in the lecture Engineering Mechanics II (Elasotstatics) but extends them significantly, while in the lecture Engineering Mechanics II (Elasotstatics) the focus was by and large limited to small deformations of simple bodies under simple loading, the lecture continuum mechanics introduces a general mathematical framework to deal with arbitrarily shaped bodies under arbitrary loading undergoing very general kinds of deformations. This lecture focuses primarily on theoretical aspects of continuum mechanics but its content is key to numerous applications in modern engineering, for example, in production, automotive, and biomedical engineering. The lecture covers:  • Fundamentals of tensor calculus  • Transformation invariance  • Tensor analysis  • Kinematics  • Material and spatial description  • Polar decomposition  • Deformation of infinitesimal line, area and volume elements  • Material and spatial description  • Partal funderial time derivatives  • Partal / material material time derivatives  • Transport theorems  • Balance equations (global and local form)  • Balance of mass  • The stress state  • Surface traction vectors  • Surface traction vectors  • Surface traction vectors  • Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)  • Balance of angular momentum  • Constitutive laws  • Constituti
	<ul> <li>Analysis</li> <li>Initial-boundary value problems and their numerical solution</li> </ul>
	dar boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
Literature	nt. Greve. Romandumsmeenanik. Liir Grundkurs tul Iligenieure uliu riiysikei
	I-S. Liu: Continuum Mechanics, Springer

Course L1534: Continuum M	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	The exercise on Continuum Mechanics explains the theoretical content of the lecture on Continuum Mechanics by way of a series of specific example problems.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer

Courses				
<b>Fitle</b> Material Modeling (L1535)	<b>Typ</b> Lecture		Hrs/wk 2	<b>CP</b> 3
Material Modeling (L1535)		ection (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
Recommended Previous	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics	I and Engineer	ing Mechanics II	at TUHH (forces
Knowledge	moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy); basics of mathematics as taught			
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
Educational Objectives		esults		
Professional Competence		v vissoolostisit	, and claste place	ticity in the reals
Knowieage	The students understand the theoretical foundations of anisotropic elasticity three-dimensional (linear) continuum mechanics. In the area of anisotropic el			
	and its application in orthotropic, transversely isotropic and isotropic mate		•	-
	compliance and how both can be characterized by appropriate parameters. M			
	in the time and frequency domain using the concepts of relaxation modulus,			-
	the area of elasto-plasticity, the students know the concept of yield stress	or (in higher dir	nensions) yield s	urface and of pla
	potential. Additionally, the know the concepts of ideal plasticity, hardening	ng and weaken	ing. Moreover, th	hey know von-M
	plasticity as a specific model of elasto-plasticity.			
Skills	The students can independently identify and solve problems in the area of ma	aterials modelin	g and acquire the	knowledge to do
	This holds in particular for the area fo anisotropically elastic, viscoelastic and			
	students can independently develop models for complex material behavi		-	•
	understand relevant literature and identify the relevant results reported the			
	developed or found in the literature in computational software (e.g., based of calculations.	on the finite ele	ment method) an	id use it for pract
Personal Competence				
Social Competence				
	to discuss challening problems of materials modeling with experts using the proper terminoloy, to identify and ask critical			
	questions in such discussions and to identify and discuss potential caveats in		-	
Autonomy	The students have the ability to independently develop abstract models that allow them to classify observed phenomena within a			
	more general abstract framework and to predict their further evolution. Mo			
	also limitations of mathematical models and can thus independently decide v	when and to whi	ch extent they m	ake sense as a b
	for decisions.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement				
Examination				
Examination duration and scale				
	Materials Science: Specialisation Modeling: Elective Compulsory			
Following Curricula		Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective		, , ,	
	Biomedical Engineering: Specialisation Medical Technology and Control Theor		pulsory	
	Biomedical Engineering: Specialisation Management and Business Administra	tion: Elective Co	mpulsory	
	Product Development, Materials and Production: Core Qualification: Elective C	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Ele	ective Compulso	rv	

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: 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 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. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Robert Meißner, Prof. Kaline Pagnan
	Furlan
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.

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Courses				
Title	ala sulas Biala su (1.0206)	Тур	Hrs/wk	СР
Introduction to Biochemistry and M		Lecture	2	3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully students	s have reached the following learning results		
Professional Competence	Arter taking part successibility, students	s have reached the following learning results		
	The students can			
Momeage	The stadents can			
	<ul> <li>describe basic biomolecules;</li> </ul>			
	explain how genetic information			
	<ul> <li>explain the connection between</li> </ul>	DNA and proteins;		
Skills	The students can			
	<ul> <li>recognize the importance of mol</li> </ul>	lecular parameters for the course of a disease;		
	describe selected molecular-diag			
	explain the relevance of these p	rocedures for some diseases		
Danas al Camartanas				
Personal Competence	The students can participate in discuss	ions in research and modising on a technical love	N.	
Social Competence	The students can participate in discuss	ions in research and medicine on a technical leve	:1.	
	Students will have an improved under	rstanding of current medical problems (e.g. Cor	ona pandemic)and wil	l be able to expla
	these issues to others.			
4.4	<del>-</del>		and a bottom of	
Autonomy	The students can develop an understar	nding of topics from the course, using technical lif	terature, by themselves	5.
	Students will be better equipped to rec	ognize fake news in the media regarding medical	research topics.	
Workload in Hours	Independent Study Time 62, Study Tim	ne in Lecture 28		
Credit points	3			
Course achievement				
Examination				
Examination duration and	60 minutes			
Scale Assignment for the	General Engineering Science (German	nrogram 7 semester). Specialisation Riomedical	Engineering: Compulso	in/
		program, 7 semester): Specialisation Biomedical an program, 7 semester): Specialisation Mech		
ronowing curricula	Compulsory	an program, 7 semester). Specialisation Meen	arrical Engineering, 1	ocus bioinechani
	· ·	ledical Technology: Elective Compulsory		
	Engineering Science: Specialisation Bio	3, , ,		
	• • •	program, 7 semester): Specialisation Biomedical E	Engineering: Compulsor	У
	Mechanical Engineering: Specialisation		•	
	Biomedical Engineering: Specialisation	Management and Business Administration: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation	Artificial Organs and Regenerative Medicine: Elec	ctive Compulsory	
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation	Implants and Endoprostheses: Elective Compulso	ory	
	Technomathematics: Specialisation III.			

Course L0386: Introduction t	o 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		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical technic	ques is recommended.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reach	ed the following learning results		
<b>Professional Competence</b>				
Knowledge	The students can describe the materials of the hun use.	nan body and the materials being used	d in medical engineerir	ng, and their fields
Skills	The students can explain the advantages and disac	dvantages of different kinds of biomate	erials.	
Personal Competence				
Social Competence	The students are able to discuss issues related to	materials being present or being used	for replacements with	student mates an
	the teachers.			
Autonomy	The students are able to acquire information on the	eir own. They can also judge the inform	mation 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: Specia	alisation II. Process Engineering and Bi	otechnology: Elective (	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid	Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Org	•	tive Compulsory	
	Biomedical Engineering: Specialisation Implants an	d Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Tec	,	, ,	
	Biomedical Engineering: Specialisation Managemer			
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective	Compulsory	

Course L0593: Biomaterials			
Typ			
Hrs/wk			
	ndependent 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		
	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. Book Rates 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 M0808: Finite					
Courses					
Title		Тур	Hrs/wk	СР	
Finite Element Methods (L0291)		Lecture	2	3	
Finite Element Methods (L0804)		Recitation Section (larg	e) 2	3	
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)				
Knowledge	Mathematics I, II, III (in particular differe	ntial equations)			
Educational Objectives	After taking part successfully, students I	nave reached the following learning results			
Professional Competence	3 (	<u> </u>			
Knowledge	The students possess an in-depth kno	wledge regarding the derivation of the finite	element method and	are able to give	
	overview of the theoretical and methodi			, , , , , , , , , , , , , , , , , , ,	
Skills	· ·	gineering problems by formulating suitable fin	te elements, assembli	ng the correspondi	
	system matrices, and solving the resulti	ng 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.			ite element routine	
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56			
Credit points	6				
Course achievement	Compulsory Bonus Form	Description			
	No 20 % Midterm				
Examination	Written exam				
Examination duration and	120 min				
scale	C. I. F. day of the Control of the C				
_	Civil Engineering: Core Qualification: Co				
Following Curricula	Energy Systems: Core Qualification: Elec	· · ·			
	Aircraft Systems Engineering: Core Qual	incation: Elective Compulsory ing: Specialisation II. Mechatronics: Elective Co	mnulsory		
		ing: Specialisation II. Product Development and		Compulsory	
	Mechatronics: Core Qualification: Compu		Jaaca on Licenve C		
	· ·	mplants and Endoprostheses: Compulsory			
	• • •	Management and Business Administration: Elec	tive Compulsory		
		Medical Technology and Control Theory: Elective			
		Artificial Organs and Regenerative Medicine: Ele			
	Product Development, Materials and Pro	•			
	Technomathematics: Specialisation III. E	ngineering Science: Elective Compulsory			
	Theoretical Mechanical Engineering: Cor	e Qualification: Compulsory			

Course L0291: Finite Elemen	ourse 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	urse L0804: Finite Element Methods		
Тур	Recitation Section (large)		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Otto von Estorff		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polyme		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible				
Admission Requirements				
	Basics: chemistry / physics / material sc	ience		
Knowledge Educational Objectives		have reached the following learning results		
Professional Competence		mave reactied the following learning results		
•		tics and define the necessary testing and analy:	sis	
Mowicage	stadents can use the knowledge of plas	ties and define the necessary testing and analy.	515.	
	They can explain the complex relationsh	nips structure-property relationship and		
	the interactions of chemical structure of	the polymers, including to explain neighboring	contexts (e.g. sustaina	bility, environmenta
	protection).			
CI-iII-	Charles are assemble of			
SKIIIS	Students are capable of			
	- using standardized calculation meth	ods in a given context to mechanical proper	rties (modulus, streng	th) to calculate an
	evaluate the different materials.			
	- selecting appropriate solutions for me	chanical recycling problems and sizing example	stiffness, corrosion res	sistance.
		3		
Personal Competence				
Social Competence	ence Students can			
	- arrive at funded work results in hetero	genius groups and document them.		
	- provide appropriate feedback and handle feedback on their own performance constructively.			
	- provide appropriate reedback and nam	ule reeuback on their own performance construi	ctively.	
Autonomy	Students are able to			
,				
	- assess their own strengths and weakne	esses.		
	- assess their own state of learning in sp	pecific terms and to define further work steps or	this basis.	
	assess possible consequences of their	professional activity		
	- assess possible consequences of their	professional activity.		
Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	,	• • • • • • • • • • • • • • • • • • • •		
Following Curricula		mplants and Endoprostheses: Compulsory	ativa Campulara	
		Artificial Organs and Regenerative Medicine: Ele Management and Business Administration: Elect		
		Management and Business Administration: Elective Medical Technology and Control Theory: Elective		
		oduction: Specialisation Production: Elective Cor		
	· ·	oduction: Specialisation Materials: Elective Com		
	'	oduction: Specialisation Product Development: E	•	
	Theoretical Mechanical Engineering: Spe	ecialisation Materials Science: Elective Compuls	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

Module M0632: Rege	nerative Medici	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 succ	essfully, students have re	ached the following learning results		
<b>Professional Competence</b>					
Knowledge	After successful comp	oletion of the module stu	dents will be able to describe the basic	methods of regenera	tive medicine and t
	explain the use of the	tissue cells for different n	nethods of tissue engineering. They are a	ble to give a basic ov	erview of methods for
	the cultivation of anim	nal and human cells.			
	The students can ou	Itline the actual concept	s of Tissue Engineering and regenerat	ive medicine and ca	an explain the basi
		of the discussed topics.			
CI-III-	A 64				
SKIIIS	After successful comp	letion of the module stude	ents are		
	able to use med	dical databases for acquir	ierung and presentation of relevant up-to	-date data independe	ntly
	able to present	their work results in the f	orm of presentations		
	able to carry out	ut basic cell culture metho	ds and the corresponding analysis indep	endently	
	able to analyse	and evaluate current res	earch topics for Tissue Engineering and re	egenerative medicine.	
Personal Competence					
Social Competence	Students are able to v	work together as a team w	vith 2-4 students to solve given tasks and	discuss their results	in the plenary and t
	defend them.				
	Ctudents are able to r	aflect their work erally an	d discuss it with other students and toach	a a ra	
	Students are able to r	effect their work orally an	d discuss it with other students and teach	iers.	
Autonomy					
Autonomy					
	After completion of	this module, participants	s will be able to solve a technical pr	oblem in teams of	approx. 2-4 person
	independently including	ng a presentation of the re	esults.		
Workload in Hours	Independent Study Tir	me 124, Study Time in Led	cture 56		
Credit points		,			
Course achievement		Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / prot	ocol for lecture series	
Examination	Presentation				
Examination duration and	Oral presentation + d	iscussion (30 min)			
scale					
Assignment for the	Biomedical Engineering	ng: Specialisation Implants	and Endoprostheses: Elective Compulso	ry	
Following Curricula	•		Organs and Regenerative Medicine: Com		
	_		ment and Business Administration: Election		
	Biomedical Engineering	ng: 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	

Implants and Fracture Healing
Typ         Hrs/wk         CP           376)         Lecture         2         3
Prof. Michael Morlock
None
It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".
After taking part successfully, students have reached the following learning results
The students can describe the different ways how bones heal, and the requirements for their existence.
The students can name different treatments for the spine and hollow bones under given fracture morphologies.
The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Independent Study Time 62, Study Time in Lecture 28
3
None
Written exam
90 min
General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
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
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
Literature	Carbona V.D. Orthan adiable Discoverheads
Literature	Cochran V.B.: Orthopädische Biomechanik
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics  White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Courses		
Title	Typ Hrs/w	
Microsystems Technology (L0724)		4
Microsystems Technology (L0725)		2
Module Responsible		
Admission Requirements		
Recommended Previous	, , , , , , , , , , , , , , , , , , ,	
Knowledge		
Educational Objectives		
Professional Competence		
Knowledge	Students are able	
	to present and to explain current fabrication techniques for microstructures and especially meti	nods for the fabrication
	microsensors and microactuators, as well as the integration thereof in more complex systems	
	to explain in details operation principles of microsensors and microactuators and	
	to discuss the potential and limitation of microsystems in application.	
Skills	Students are capable	
	to analyze the feasibility of microsystems,	
	to analyze the leasibility of microsystems,	
	to develop process flows for the fabrication of microstructures and	
	to apply them.	
	то арру them.	
B		
Personal Competence		
Social Competence		
	Students are able to plan and carry out experiments in groups, as well as present and represent the	results in front of oth
	These social skills are practiced both during the preparation phase, in which the groups work out an	d present the theory,
	during the follow-up phase, in which the groups prepare, document and present their practical experience	es.
Autonomy	The independence of the students is demanded and promoted in that they have to transfer and apply	what they have learne
	ever new boundary conditions. This requirement is communicated at the beginning of the semester and	consistently practiced (
	the exam. Students are encouraged to work independently by not being given a solution, but by learning	ig to work out the solu
	step by step by asking specific questions. Students learn to ask questions independently when they	are faced with a probl
	They learn to independently break down problems into manageable sub-problems.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement	Compulsory Bonus Form Description  Yes None Subject theoretical and Studierenden führen in Kleingruppen ein Laborprak	tikum durch lede Gru
	practical work präsentiert und diskutiert die Theorie sowie die Erge	
	vor dem gesamten Kurs.	omise mier Eabortang.
Examination	-	
Examination duration and		
examination duration and scale		
Assignment for the		v
Assignment for the Following Curricula		у
Following Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostneses: 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	

ourse L0724: Microsystems Technology		
Тур	Lecture	
Hrs/wk		
СР	4	
Workload in Hours		
Lecturer		
Language		
Cycle		
Content		
	<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> <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-tul relationship)</li> <li>System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>	
Literature		
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009  T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010	
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008	

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

Module M0634: Introd	duction into	о Мес	dical Technology	and Systen	าร		
Courses							
Title					Tree	Hrs/wk	СР
Introduction into Medical Technolog	ny and Systems (I	0342)			Typ Lecture	2 2	3
Introduction into Medical Technolog					Project Seminar	2	2
Introduction into Medical Technolog					Recitation Section (large)	1	1
Module Responsible	Prof. Alexander	r Schlae	fer				
Admission Requirements	None						
Recommended Previous	principles of ma	ath (alg	ebra, analysis/calculus)				
Knowledge	principles of st	tochasti	cs				
	principles of pr	ogramn	ning, R/Matlab				
Educational Objectives	After taking pa	rt succe	essfully, students have re	eached the followi	ng learning results		
<b>Professional Competence</b>							
Knowledge	The students of	can exp	plain principles of medic	cal technology, in	ncluding imaging systems,	computer aided s	surgery, and medica
	information sys	stems. 1	They are able to give an	overview of regula	atory affairs and standards	in medical technol	ogy.
Skills	The students a	re able	to evaluate systems and	I medical devices	in the context of clinical ap	oplications.	
Personal Competence							
Social Competence					ject, and define tasks that		
	The students ca	an critic	cally reflect on the result	s of other groups	and make constructive sug	gestions for improv	rement.
Autonomy					nent their work results.	They can critically	evaluate the results
	achieved and p	resent	them in an appropriate r	nanner.			
Workload in Hours	Independent St	tudy Tin	ne 110, Study Time in Le	ecture 70			
Credit points	6						
Course achievement	Compulsory Bon	us	Form	Description			
	Yes 10 °	%	Written elaboration				
	Yes 10 °	%	Presentation				
Examination	Written exam						
Examination duration and	90 minutes						
scale							
Assignment for the	_				ecialisation Biomedical Eng		ory
Following Curricula	·			-	ng Science: Elective Compu	ulsory	
			sation II. Application: Ele				
			alification: Elective Com				
	3		Core Qualification: Elect	, ,			
			Specialisation Biomedica				
	_	-			ecialisation Biomedical Eng		ry
	·		3 3 1		& Engineering Science: Ele	, ,	
	_		•		enerative Medicine: Electiv	re Compulsory	
	_		• .	·	eses: Elective Compulsory		
	_		•		Control Theory: Elective Co		
	_				ss Administration: Elective	Compulsory	
	recnnomathem	iatics: S	Specialisation III. Enginee	ering Science: Elec	Live 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	Bernhard Priem, "Visual Computing for Medicine", 2014
	Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097)
	Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015
	Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014
	H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687)
	Wolfgang Drexler, "Optical Coherence Tomography", 2008
	Kramme, "Medizintechnik", 2011
	Thorsten M. Buzug, "Computed Tomography", 2008
	Otmar Scherzer, "Handbook of Mathematical Methods in Imaging", 2015
	Weishaupt, "Wie funktioniert MRI?", 2014
	Paul Suetens, "Fundamentals of Medical Imaging", 2009
	Vorlesungsunterlagen
L	

Course L0343: Introduction i	rse 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	se L1876: Introduction into Medical Technology and Systems		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses						
Γitle			Тур	Hrs/wk	СР	
Robotics and Navigation in Medicin			Lecture	2	3	
Robotics and Navigation in Medicin			Project Seminar	2	2	
Robotics and Navigation in Medicin			Recitation Section (small)	1	1	
	Prof. Alexander Schlae	efer				
Admission Requirements	None					
Recommended Previous	<ul> <li>principles of ma</li> </ul>	ith (algebra, analysis/calculus				
Knowledge		ogramming, e.g., in Java or C+				
	<ul> <li>solid R or Matlal</li> </ul>					
Educational Objectives	After taking part succe	essfully, students have reache	d the following learning results			
Professional Competence						
Knowledge	· ·		systems in clinical contexts and illust			
	· ·	•	collision detection and safety and re-	gulations. Student	s can assess typ	
	systems regarding des	sign and limitations.				
Skills	The students are able	to design and evaluate naviga	ation systems and robotic systems for m	edical applications	5.	
Personal Competence						
Social Competence	The students are able	to grasp practical tasks in g	groups, develop solution strategies inde	pendently, define	work processes	
	work on them collabor	atively.				
	The students are able	to collaboratively organize	heir work processes and software solu	tions using virtual	communication	
	software management	tools.				
	The students can crit	cically reflect on the results	of other groups, make constructive su	uggestions for imp	provement, and a	
	incorporate them into	their own work.				
Autonomy	The students can ass	ess their level of knowledge	and independently control their learning	ng processes on	this basis as well	
	document their work results. They can critically evaluate the results achieved and present them in an appropriate argumentative					
	manner to the other gi	roups.				
Workload in Hours	Independent Study Tin	ne 110, Study Time in Lecture	70			
Credit points	6					
Course achievement	Compulsory Bonus		Description			
	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and .	90 minutes					
scale						
Assignment for the		,	lineering: Elective Compulsory			
Following Curricula		Specialisation Medical Techn		Compulsor		
	_		isation II. Electrical Engineering: Elective		Commule	
	_		isation II. Process Engineering and Biote	cimology: Elective	Compulsory	
	· · · · · · · · · · · · · · · · · · ·		I Robotics: Elective Compulsory	Compulsor		
	_	• .	ans and Regenerative Medicine: Elective	: Compuisory		
	_		Endoprostheses: Elective Compulsory	mnulsory		
	_	•	nology and Control Theory: Elective Cor			
	_		and Business Administration: Elective ( ecialisation Product Development: Electi			
	· ·	·	ecialisation Product Development: Electi ecialisation Production: Elective Compuls			
		maccinals and Froduction, 50				
	· ·	·	ecialisation Materials: Elective Compulso	-		

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 M0752: Nonlii	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
-				
Recommended Previous				
Knowledge	Calculus			
	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached t	the following learning results		
Professional Competence				
Knowledge				
	Students are able to reflect existing terms and	concepts in Nonlinear Dynamics and	to develop and res	earch new terms and
	concepts.	de la Companya de la		
	Students are able to denote and expand method	ds of modeling and analysis for nonli	near dynamicai sys	tems.
Skills	5			
	Students are able to apply existing methods and	•		
	Students are able to develop novel methods and	a procedures for nonlinear dynamica	i systems.	
Personal Competence				
Social Competence				
	Students can analyze problems of nonlinear dyr     Students can ashious solution proceedures for pro-	- '	uma alaa in arauna	
	<ul> <li>Students can achieve solution procedures for pr</li> </ul>	oblems of nonlinear dynamical syste	enis aiso in groups.	
Autonomy	Charles and a hall he amount a his an according to		altrial calls	
	<ul> <li>Students are able to approach given research to</li> <li>Students are able to identify and follow up nove</li> </ul>	-	idividually.	
	Students are usic to identify and follow up hove	rescuren tusks by themselves.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Core Qualification: Elect	ive Compulsory		
Following Curricula	International Management and Engineering: Specialisa	ation II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisati	•	ry	
	Mechatronics: Specialisation System Design: Elective (			
	Mechatronics: Specialisation Intelligent Systems and R		ro Compulsor	
	Biomedical Engineering: Specialisation Artificial Organ	-	e Compuisory	
	Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Medical Techno		ampulsory	
	Biomedical Engineering: Specialisation Medical Technic Biomedical Engineering: Specialisation Management a	•		
	Product Development, Materials and Production: Core		Compaisory	
	Theoretical Mechanical Engineering: Core Qualification			

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		
	<ul> <li>One dimensional problems         <ul> <li>Linear Stability</li> <li>Local Bifurcations</li> <li>Synchronisation</li> </ul> </li> <li>Two dimensional problems         <ul> <li>Limit Cycles</li> <li>Global Bifurcations</li> </ul> </li> <li>Chaos         <ul> <li>Lorenz Equations</li> <li>Fractals and Strange Attractors</li> <li>Predictability and Horizons</li> </ul> </li> </ul>		
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.		

	conductor Technology			
Courses				
Title		Тур	Hrs/wk	СР
Semiconductor Technology (L0722		Lecture	4	4
Semiconductor Technology (L0723	5)	Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
<b>Recommended Previous</b>	Basics in physics, chemistry, material science and semi	conductor devices		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
<b>Professional Competence</b>				
Knowledge				
	Students are able			
	to describe and to explain current fabrication techn	iques for Si and GaAs substrates	,	
	to discuss in details the relevant fabrication	processes, process flows and	the impact thereof or	n the fabrication (
	semiconductor devices and integrated circuits and			
	to present integrated process flows.			
51.W				
Skills				
	Students are capable			
	to analyze the impact of process parameters on the	processing results,		
	to select and to evaluate processes and			
	to develop process flows for the fabrication of semi	conductor devices.		
Personal Competence				
Social Competence				
Social Competence				
	Students are able to plan and carry out experiments	n groups, as well as present ar	nd represent the result	ts in front of other
	These social skills are practiced both during the prep			sent the theory, ar
	during the follow-up phase, in which the groups prepare	, document and present their pr	actical experiences.	
A	The first control of the state	and the first that the state of the state of	6	h
Autonomy	The independence of the students is demanded and poly ever new boundary conditions. This requirement is com-			
	the exam. Students are encouraged to work independe			
	step by step by asking specific questions. Students le			
	They learn to independently break down problems into	·	,	
Workload in Hours				
Credit points				
Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics a	nd Microsystems Technology: Ele	ective Compulsory	
_	Biomedical Engineering: Specialisation Artificial Organs			
-	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Electi	ve Compulsory	
	Microelectronics and Microsystems: Core Qualification:	Elective Compulsory		

L0722: Semiconducto	or Technology
Тур	Lecture
Hrs/wk	4
СР	
	Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
Cycle	3056
	<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 proces</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</li> </ul>
	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)
	<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, proxin and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique 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 anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etch 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 cont. 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

Course L0723: Semiconducto	or 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

P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	Introduction to control systems			
	Control theory and design			
	control tricolly und design			
<b>Educational Objectives</b>	After taking part successfully, students have rea	ched the following learning results		
<b>Professional Competence</b>				
Knowledge	<ul> <li>Students can explain humanoid robots.</li> </ul>			
	Students learn to apply basic control conc	epts for different tasks in humanoid re	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	<ul> <li>Students are capable of developing solution</li> </ul>	ons in interdisciplinary teams and pre	sent them	
	<ul> <li>They are able to provide appropriate feed</li> </ul>	back and handle constructive criticisn	n of their own results	
Autonomy				
	Students evaluate advantages and draw	backs of different forms of present	ation for specific tasks	and select the bes
	solution			
	Students familiarize themselves with a supply that a scientific discussion developes.	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	ire 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 T	•		
	Biomedical Engineering: Specialisation Managen Theoretical Mechanical Engineering: Specialisati			
	Theoretical Mechanical Engineering. Specialisati	on nobotics and computer science. El	ceare compaisory	

Course LOCCO Homes id Bo	h-Ati
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).

Courses				
Γitle	(7. 1) (1.0550)	Тур	Hrs/wk	СР
inear and Nonlinear System Ident	I	Lecture	2	3
Module Responsible				
Admission Requirements	None			
Recommended Previous	Classical control (frequency respo	nse, root locus)		
Knowledge	State space methods			
	Discrete-time systems			
	Linear algebra, singular value dec	omposition		
	Basic knowledge about stochastic	processes		
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	. Students can explain the service	framousely of the prediction error	and its application to -	variaty of lines
		I framework of the prediction error method a	and its application to a	variety of linear an
	nonlinear model structures  They can explain how multilayer r	perceptron networks are used to model nonlin	ear dynamics	
		nate predictive control scheme can be based	•	ıls
		pace identification and its relation to Kalman		
	, ,		,	
Skills		the predicition error method to the experi	mental identification of	linear and nonlinea
	models for dynamic systems	, ,		
		a nonlinear predictive control scheme based	on a neural network mo	del
		space algorithms to the experimental identific		
	They can do the above using stan	dard software tools (including the Matlab Syst	em Identification Toolbo	ox)
Personal Competence				
Social Competence	Students can work in mixed groups on s	pecific problems to arrive at joint solutions.		
Autonomy	Students are able to find required inforn	nation in sources provided (lecture notes, liter	ature, software docume	ntation) and use it t
	solve given problems.			
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Co	ntrol and Power Systems Engineering: Elective	e Compulsory	
Following Curricula	Mechatronics: Specialisation Intelligent S	Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Des	sign: Elective Compulsory		
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: El	lective Compulsory	
	Biomedical Engineering: Specialisation II	mplants and Endoprostheses: Elective Compu	sory	
	Biomedical Engineering: Specialisation N	ledical Technology and Control Theory: Comp	ulsory	
		lanagement and Business Administration: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Cor	e Qualification: Elective Compulsory		

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

Module MO840: Optin	nal and Robust Control			
ourses				
itle		Тур	Hrs/wk	СР
ptimal and Robust Control (L0658		Lecture	2	3
optimal and Robust Control (L0659	ı	Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous	Classical control (frequency response, roo	t locus)		
Knowledge	State space methods			
	<ul> <li>Linear algebra, singular value decomposit</li> </ul>	ion		
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence	, ,			
Knowledge				
	Students can explain the significance of th			
	They can explain the duality between opti	·		
	They can explain how the H2 and H-infinit			
	<ul> <li>They can explain how an LQG design prob</li> <li>They can explain how model uncertainty</li> </ul>	·		
	They can explain how - based on the small	,		3
	an uncertain plant.	an gam theorem - a robust controller can g	adianice stability	and periormance
	They understand how analysis and synthe	sis conditions on feedback loops can be rep	resented as linear	matrix inequalitie
g/ ///				
Skills	Students are capable of designing and tur	ning LQG controllers for multivariable plant r	nodels.	
	They are capable of representing a H2 or	H-infinity design problem in the form of a g	eneralized plant, a	and of using standa
	software tools for solving it.			
	<ul> <li>They are capable of translating time and</li> </ul>	frequency domain specifications for control	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	uncertainty model for an uncertain system	n, and of designir	ng a mixed-object
	robust controller.		(1.5.1)	
	They are capable of formulating analysis  I MI solvers for solving them.	and synthesis conditions as linear matrix in	equalities (LMI), a	ind of using standa
	<ul><li>LMI-solvers for solving them.</li><li>They can carry out all of the above using s</li></ul>	standard software tools (Matlah rohust conti	rol toolbox)	
	iney can carry out an or and above abring t	canadia soluma e toolo (riatias rosase toila	0. 100.000,	
Personal Competence				
,	Students can work in small groups on specific pr	•		
Autonomy	Students are able to find required information in	sources provided (lecture notes, literature,	software docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lect	turo 56		
Credit points		ture 50		
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and	, , , ,	oulsory	
Following Curricula	Energy Systems: Core Qualification: Elective Con Aircraft Systems Engineering: Core Qualification:			
	Mechatronics: Specialisation Intelligent Systems			
	Mechatronics: Specialisation Intelligent Systems  Mechatronics: Specialisation System Design: Elec	, ,		
	Biomedical Engineering: Specialisation Artificial (		Compulsory	
	Biomedical Engineering: Specialisation Implants	•		
	Biomedical Engineering: Specialisation Medical T		npulsory	
	Biomedical Engineering: Specialisation Managem	**		
	Product Development, Materials and Production:	Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Production:	Specialisation Production: Elective Compuls	ory	
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Core Qualifi	cation: 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	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 M	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	principles (strategic planning, decisi	on theory, pro	ject management,
	international business)			
	Bachelor-level Marketing Knowledge (Marketing Inst		egies, Basics o	f Buying Behavior)
	Unerstanding the differences beweetn B2B and B2C     Understanding of the importance of managing in a continuous.			
	<ul> <li>Understanding of the importance of managing inno</li> <li>Good English proficiency; presentation skills</li> </ul>	ation in global industrial markets		
	2004 English pronoceine, presentation skills			
Educational Objectives	After taking part successfully, students have reached the	ollowing learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innovati	re poroducts and services		
	Approaches for analyzing the current market situation	on and the future market developmen	t	
	The gathering of information about future customer			
	Concepts and approaches to integrate lead users at			
	<ul> <li>Approaches and tools for ensuring customer-orienta</li> <li>Marketing mix elements that take into consideration</li> </ul>			
	services	the specime requirements and end	icinges or illino	active produces and
	Pricing methods for new products and services			
	The organization of complex sales forces and perso	nal 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 marketi	ng and innovation strategies		
	<ul> <li>Analyze markets by applying market and technolog</li> </ul>	portfolios		
	Conduct forecasts and develop compelling scenario			
	Translate customer needs into concepts, prototype		fully apply adv	anced methods for
	<ul> <li>customer-oriented product and service developmer</li> <li>Use adequate methods to foster efficient diffusion of</li> </ul>			
	Choose suitable pricing strategies and communications			
	Make strategic sales decisions for products and services.			
	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			
	Acquire knowledge independently in the specific co	start and to man this knowledge as at	her now com-1	av problem fielde
	Consider proposed business actions in the field of m	,	ner new compi	ex problem neids.
	Consider proposed business detroits in the field of the			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points				
Course achievement				
	Subject theoretical and practical work	ation		
Examination duration and scale	Written elaboration, excercises, presentation, oral particip	สมายา		
Assignment for the	Global Technology and Innovation Management & Entrepr	neurship: Core Qualification: Flective	Compulsory	
Following Curricula		•		
	Mechanical Engineering and Management: Specialisation I		•	
	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Implants and Endo			
	Biomedical Engineering: Specialisation Medical Technology		sory	
	Biomedical Engineering: Specialisation Management and E	usiness 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	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	

	ocess Engineering - Funda	mentals			
Courses					
itle			Тур	Hrs/wk	СР
ioprocess Engineering - Fundame	ntals (L0841)		Lecture	2	3
ioprocess Engineering- Fundamer	tals (L0842)		Recitation Section (large)	2	1
ioprocess Engineering - Fundame	ntal Practical Course (L0843)		Practical Course	2	2
Module Responsible	Prof. Andreas Liese				
Admission Requirements	None				
Recommended Previous	module "organic chemistry", module '	fundamentals for proces	s engineering"		
Knowledge					
<b>Educational Objectives</b>	After taking part successfully, student	s have reached the follow	wing learning results		
<b>Professional Competence</b>					
Knowledge	Students are able to describe the bas	ic concepts of bioprocess	engineering. They are able to	o classify different	types of kinetics
	enzymes and microorganisms, as w	ell as to differentiate d	ifferent types of inhibition.	The parameters o	f stoichiometry
	rheology can be named and mass t	ransport processes in b	ioreactors can be explained.	The students are	capable to exp
	fundamental bioprocess management	, sterilization technology	and downstream processing i	n detail.	
Skills	After successful completion of this mo	odule, students should be	able to		
	describe different kinetic anno	aches for growth and sub	ostrate-untake and to calculate	e the correspondir	ia narameters
	describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters      product qualitatively the influence of contrav generation of redex equivalents and growth inhibition on the				
	predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the formentation process.				
	fermentation process				
	<ul> <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)</li> </ul>				
	to compare them as well as to apply them to current biotechnical problem				
	propose solutions to complicate	,		nonding models	
	propose solutions to complicate	a stoccomological prosi-		portaining into decis	
	<ul> <li>to explore new knowledge reso</li> </ul>	urces and to apply the ne	ewly gained contents		
	<ul> <li>identify scientific problems with</li> </ul>	n concrete industrial use	and to formulate solutions.		
	to document and discuss their	procedures as well as res	ults in a scientific manner		
Personal Competence					
Social Competence	After completion of this module partic	ipants should be able to	debate technical questions in	small teams to e	nhance the abilit
	take position to their own opinions an	d increase their capacity	for teamwork in engineering a	and scientific envir	onments.
	After committee of this mandale worth				
4	y After completion of this module participants will be able to solve a technical problem in a team independently by orga				
Autonomy		in a planum	ive a tecimical problem in a d	eam maepenaema	y by organizing t
Autonomy	workflow and to present their results	in a plenum.	ive a technical problem in a d	eam muepenuenti	y by organizing t
Workload in Hours	workflow and to present their results  Independent Study Time 96, Study Time		ive a tecinical problem in a d	eam muepenuemu	y by organizing t
Workload in Hours Credit points	workflow and to present their results Independent Study Time 96, Study Time 6	me in Lecture 84	ve a technical problem in a d	eam muepenuenti	y by organizing ti
Workload in Hours	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form	me in Lecture 84  Description	ive a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject thee	me in Lecture 84  Description	ive a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points Course achievement	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject theo practical work	me in Lecture 84  Description	ive a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points Course achievement Examination	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject theo practical work  Written exam	me in Lecture 84  Description	ve a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points Course achievement	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject theo practical work	me in Lecture 84  Description	ve a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points Course achievement  Examination Examination duration and scale	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject theorem practical work  Written exam  90 min	me in Lecture 84  Description pretical and	ive a technical problem in a d	eani independenti	y by organizing t
Workload in Hours Credit points Course achievement  Examination Examination duration and scale Assignment for the	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject their practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific	Description pretical and			y by organizing t
Workload in Hours Credit points Course achievement  Examination Examination duration and scale	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject their practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific Green Technologies: Energy, Water, Core	Description pretical and ation: Compulsory	oresource Technology: Elective	e Compulsory	y by organizing t
Workload in Hours Credit points Course achievement  Examination Examination duration and scale Assignment for the	workflow and to present their results  Independent Study Time 96, Study Time  Compulsory Bonus Form  Yes 5 % Subject their practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific Green Technologies: Energy, Water, C Biomedical Engineering: Specialisation	Description oretical and ation: Compulsory Climate: Specialisation Bio	oresource Technology: Elective generative Medicine: Compuls	e Compulsory	y by organizing t
Workload in Hours Credit points Course achievement  Examination Examination duration and scale Assignment for the	workflow and to present their results  Independent Study Time 96, Study Time  Compulsory Bonus Form  Yes 5 % Subject their practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific Green Technologies: Energy, Water, C Biomedical Engineering: Specialisatio Biomedical Engineering: Specialisatio	Description oretical and ation: Compulsory Climate: Specialisation Bio n Artificial Organs and Re n Implants and Endoprost	oresource Technology: Elective generative Medicine: Compuls theses: Elective Compulsory	e Compulsory sory	y by organizing ti
Workload in Hours Credit points Course achievement  Examination Examination duration and scale Assignment for the	workflow and to present their results  Independent Study Time 96, Study Time  6  Compulsory Bonus Form  Yes 5 % Subject thee practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific Green Technologies: Energy, Water, Companies and Engineering: Specialisation Biomedical Engineering: Specialisation Biomedical Engineering: Specialisation Biomedical Engineering: Specialisation Biomedical Engineering: Specialisation	Description oretical and ation: Compulsory Climate: Specialisation Bio n Artificial Organs and Re n Implants and Endoprost	oresource Technology: Elective egenerative Medicine: Compuls theses: Elective Compulsory d Control Theory: Elective Com	e Compulsory sory	y by organizing ti
Workload in Hours Credit points Course achievement  Examination Examination duration and scale Assignment for the	workflow and to present their results  Independent Study Time 96, Study Time  Compulsory Bonus Form  Yes 5 % Subject their practical work  Written exam  90 min  Bioprocess Engineering: Core Qualific Green Technologies: Energy, Water, C Biomedical Engineering: Specialisatio Biomedical Engineering: Specialisatio	Description oretical and ation: Compulsory Climate: Specialisation Bio n Artificial Organs and Re n Implants and Endoprost n Medical Technology and n Management and Busin	presource Technology: Elective regenerative Medicine: Compuls theses: Elective Compulsory d Control Theory: Elective Com less Administration: Elective C	e Compulsory sory	y by organizing ti

Course L0841: Bioprocess Engineering - Fundamentals			
Тур	Lecture		
Hrs/wk	2		
СР			
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 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	
Language	DE	
Cycle	SoSe	
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out.  The students document their experiments and results in a protocol.	
Literature	Skript	

Module M1143: Applied 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 compu	iter-sciences		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product desi	gn considering targeted application of sp	ecific product	design techniques
Skills	Creative handling of processes used for scientific prepa	ration and formulation of complex produc	t design prob	olems / Application of
	various product design techniques following theoretical	·	,	
		·		
Personal Competence				
Social Competence	Students will solve and execute technical-scientific to	asks from an industrial context in small	design-team	s with application of
	common, creative methodologies.			
Autonomy	Students are enabled to optimize the design and development process according to the target and topic of the design			
	Students are educated to operate in a development tea	m		
	Students learn about the right application of creative m	ethods in engineering.		
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: Specialisat	ion II. Product Development and Production	n: Elective C	ompulsory
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation	n Product Development and Production: E	lective Comp	ulsory
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and En	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation Prod	luct Development 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 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	

	I: Introduction to Anatomy		
Courses			
Title Introduction to Anatomy (L0384)	Typ Hrs/wk CP Lecture 2 3		
	Prof. Udo Schumacher		
Admission Requirements			
	Students can listen to the lectures without any prior knowledge. Basic school knowledge of biology, chemistry / biochemis		
Knowledge	physics and Latin can be useful.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The lectures are about microscopic anatomy, describing the microscopic structure of tissues and organs, and about macrosco		
	anatomy which is about organs and organ systems. The lectures also contain an introduction to cell biology, human development and to the central nervous system. The fundamentals of radiologic imaging are described as well, using projectional x-ray and cross-sectional images. The Latin terms are introduced.		
Skills	At the end of the lecture series the students are able to describe the microscopic as well as the macroscopic assembly a functions of the human body. The Latin terms are the prerequisite to understand medical literature. This knowledge is needed understand und further develop medical devices.		
	These insights in human anatomy are the fundamentals to explain the role of structure and function for the development common diseases and their impact on the human body.		
Personal Competence			
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level. The Latin ter		
Autonomy	are prerequisite for communication with physicians on a professional level.  The lectures are an introduction to the basics of anatomy and should encourage students to improve their knowledge b themselves. Advice is given as to which further literature is suitable for this purpose. Likewise, the lecture series encourage students to recognize and think critically about biomedical problems.		
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		
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechan		
	Compulsory		
	Data Science: Specialisation II. Application: Elective 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 L0384: Introduction t	o Anatomy		
Тур	Lecture		
Hrs/wk	2		
СР	3		
		Time 62, Study Time in Lecture 28	
	Prof. Tobias Lange		
Language			
Cycle			
Content	General Anatomy		
	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	
1:4	Adolf Follow/Mi-b	J Cabillaka Dar Körner des Manschen 17 Auflage Thioma Verlag Chuttaget 2016	
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016	

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	Monthly and a second like the last and the l				
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 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 therape measures and can meet them appropriately.				
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.				
	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	None				
	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory  General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechan  Compulsory				
	Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory				
	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 t	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 M1280: MED	II: Introduction to Physiology			
Courses				
Title		Тур	Hrs/wk	СР
Introduction to Physiology (L0385)		Lecture	2	3
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	The students can			
	<ul> <li>describe the basics of the energy metabolism;</li> </ul>			
	<ul> <li>describe physiological relations in selected fields o</li> </ul>	f muscle, heart/circulation, neur	o- and sensory physio	logy.
Skills	The students can describe the effects of basic bodily fund		nd processing of inforn	nation, development
	of forces and vital functions) and relate them to similar to	echnical systems.		
Personal Competence				
Social Competence	The students can find solutions to problems in the field of		l matralagical	
	The students can find solutions to problems in the field of	priysiology, both analytical and	i metrological.	
Autonomy	The students can derive answers to questions arising in	the course and other physiolo	ogical areas, using ted	hnical 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 program, 7 semes	er): Specialisation Biomedical E	ingineering: Compulso	ry
Following Curricula	General Engineering Science (German program, 7 se	emester): Specialisation Mecha	anical Engineering, F	ocus Biomechanics:
	Compulsory			
	Data Science: Specialisation Medicine: Compulsory	51 II 0 I		
	Electrical Engineering: Specialisation Medical Technology			
	Engineering Science: Specialisation Biomedical Engineeri General Engineering Science (English program, 7 semest		agineering: Elective Co	mnulsony
	Mechanical Engineering: Specialisation Biomechanics: Co		igineering. Elective Co	inpuisury
	Biomedical Engineering: Specialisation Medical Technology		Compulsorv	
	Biomedical Engineering: Specialisation Medical Technology  Biomedical Engineering: Specialisation Management and	•		
	Biomedical Engineering: Specialisation Artificial Organs a			
	Biomedical Engineering: Specialisation Implants and Endo			
	Technomathematics: Specialisation III. Engineering Scien			

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 M1335: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techniques is a	ecommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results		
Professional Competence				
Knowledge	The students can name the different kinds of artificial limb	S.		
G1 !!!		6 1166		
SKIIIS	The students can explain the advantages and disadvantag	es of different kinds of endo	protheses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to endopro	these with student mates ar	nd the teachers.	
Autonomy	The students are able to acquire information on their own.	They can also Judge the Inf	ormation 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 Materia	ls: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective	ve Compulsory	
	Biomedical Engineering: Specialisation Management and E	Business Administration: Elec	ctive Compulsory	
	Orientation Studies: Core Qualification: Elective Compulso	•		
	Theoretical Mechanical Engineering: Specialisation Bio- an	d Medical Technology: Elect	ive Compulsory	

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

Module M1384: Case	Studies for Regenerative Medicine and Tissue Engineering
Courses	
Title	Typ Hrs/wk CP
Case Studies for Regenerative Med	dicine and Tissue Engineering (L1963) Seminar 3 6
Module Responsible	Prof. Ralf Pörtner
Admission Requirements	None
<b>Recommended Previous</b>	none
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	After successfully participating in the module case studies on regenerative medicine and tissue engineering, the students
	can recognize, how a team works together to work on a complex task
	can assign, which planning tools are required for new cell-based therapy concepts and medical products from the "proof-c
	concept" to successful market approval
	can illustrate, which obstacles and difficulties arise during the market approval of the concepts and products mentioned
CL III.	And a second for the first first to the second first first to the second first first to the second first fir
SKIIIS	After successful completion of the module students are
	able to use relevant 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 analyse and evaluate current research topics and applications for Tissue Engineering and Regenerative Medicine.
Personal Competence	
•	Students are able to work together as a team with 6-8 students to solve given tasks and discuss their results in the plenary and t
	defend them.
	Students are able to reflect their work orally and discuss it with other students and teachers.
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 6-8 perso
	independently
	including a presentation of the results.
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 Artificial Organs and Regenerative Medicine: Compulsory
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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	The students should work in working groups to develop concepts for the path from "proof of concept" to successful market approval for new cell-based therapy concepts and medical products. It is assumed that an initial test phase was successful for the respective concepts. A routine clinical application must now be established in each case. Strategies are to be developed for this.
Literature	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540

Module M0845: Feedb	pack Control in Medical Technol	ogy		
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 r	eached the following learning results		
Professional Competence				
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.			
	Internal control loops of the human body wi example in for anesthesia control.	ll be discussed in the same way like the o	design of external clo	osed loop system fo
	The handling of PID controllers and modern illustrated. The operation of simple equivalent	·	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 pro	blems in small groups and present their res	ults	
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 Le	cture 28		
Credit points	3			
Course achievement	None			_
Examination	Oral exam			
Examination duration and	20 min	_		
scale				
Assignment for the	Electrical Engineering: Specialisation Medical	Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Control a			
	Biomedical Engineering: Specialisation Implan	·	•	
	Biomedical Engineering: Specialisation Artificia	•		
	Biomedical Engineering: Specialisation Manag			
	Biomedical Engineering: Specialisation Medica	i Technology and Control Theory: Compulso	ory	

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

Mudule Mu832: Adva	nced Topics in Control	
Courses		
Title	Typ Hrs/wk CP	
Advanced Topics in Control (L0661	Lecture 2 3	
Advanced Topics in Control (L0662	Recitation Section (small) 2 3	
Module Responsible	Prof. Herbert Werner	
Admission Requirements	None	
Recommended Previous	H-infinity optimal control, mixed-sensitivity design, linear 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 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>	
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results.	
Workload in Hours	given problems.  Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination		
Examination duration and		
scale		
Searc		
Assignment for the		
Following Curricula		
	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	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"	
	Werner, H., Lecture Notes "Advanced Topics in Control"     Selection of relevant research papers made available as pdf documents via StudIP	
	Selection of relevant research papers made available as put documents via studing	

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

	ectromagnetics: Principles a				
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					
Recommended Previous Knowledge	Basic principles of physics				
<b>Educational Objectives</b>	After taking part successfully, students h	have reached the following	g 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	issue. They can define and frequency of the fields.	d exemplify the most impo They can give an overvic tical applications . They ca	ortant physical ph w over measure	nenomena and orde
Skills	Students know how to apply various med do this they can relate to and make us important effects that these models prequency, respectively, and they can a predictions. They are able to evaluate the appropriate choice.	se of the elementary solu redict for biological tissue nalyze them in a quantita	itions of Maxwell's Equations, they can order the effective way. They are able to	ns. They are able cts corresponding develop validation	to assess the mos to wavelength an strategies for thei
Personal Competence Social Competence	Students are able to work together on s English (e.g. during small group exercise	•	mall groups. They are able	to present their	results effectively i
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.				
Workload in Hours	Independent Study Time 110, Study Tim	ne 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 Mid	crowave Engineering, Opti	ics, and Electromagnetic Co	mpatibility: Electi	ve Compulsory
Following Curricula				. , , , , , , , , , , , , , , , , , , ,	,,
-	International Management and Engineer	ing: Specialisation II. Elect	trical Engineering: Elective	Compulsory	
	Biomedical Engineering: Specialisation M	Management and Business	Administration: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation I	mplants and Endoprosthes	ses: Elective Compulsory		
	Biomedical Engineering: Specialisation A	Artificial Organs and Reger	nerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation N	Medical Technology and Co	ontrol Theory: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Spe	ecialisation Bio- and Medic	al Technology: Elective Cor	npulsory	

Course L0371: Bioelectromag	gnetics: Principles and Applications	
Тур	Lecture	
Hrs/wk	3	
СР	5	
Workload in Hours	ndependent Study Time 108, Study Time in Lecture 42	
	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)	

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

## **Specialization Management and Business Administration**

Module M0623: Intelligent Systems in Medicine						
Courses						
Title				Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0				Lecture	2	3
Intelligent Systems in Medicine (L0				Project Seminar	2	2
Intelligent Systems in Medicine (L0		_		Recitation Section (small)	1	1
Module Responsible	<b>†</b>	iefer				
Admission Requirements	<b>†</b>					
Recommended Previous		ath (algebra, analysis/cal	lculus)			
Knowledge	<ul> <li>principles of st</li> </ul>	cochastics				
	principles of principles	rogramming, Java/C++ ar	nd R/Matlab			
	<ul> <li>advanced prog</li> </ul>	gramming skills				
Educational Objectives	After taking part succ	cessfully, students have re	eached the followin	na learnina results		
Professional Competence	Arter taking part sack	cessiany, stadents have it	caerica the followii	ig rearring resures		
•	The students are abl	e to analyze and solve c	linical treatment nl	anning and decision suppo	rt problems using	methods for search
Knowicage				classification and their res		
				for representing medical I		
				clinical nature of the data		
	and safety requireme	ents.				
a						
SKIIIS	_			ods for classification, regre	ssion, and predicti	on. They can assess
	the methods based o	n actual patient data and	evaluate the imple	emented methods.		
Personal Competence						
Social Competence						
	work on them collaboratively.					
	The students can critically reflect on the results of other groups, make constructive suggestions for improvement and also					
	incorporate them into their own work.					
Autonomy	The students can assess their level of knowledge and document their work results. They can critically evaluate the results achieved					
	and present them in	an appropriate argument	ative manner to the	e other groups.		
Workload in Hours		ime 110, Study Time in Le	ecture /0			
Credit points	·	Form	Description			
Course achievement	Yes 10 %	Written elaboration	Description			
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	•					
scale						
Assignment for the	Computer Science: S	pecialisation II: Intelligend	ce Engineering: Ele	ctive Compulsory		
Following Curricula	·	g: Specialisation Medical 1				
	,	•		ods in Biomedical Imaging	Compulsory	
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Biomedical Engineeri	ng: Specialisation Artificia	al Organs and Rege	nerative Medicine: Elective	Compulsory	
	Biomedical Engineeri	ng: Specialisation Implan	ts and Endoprosthe	eses: Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation Medica	l Technology and C	Control Theory: Elective Cor	npulsory	
	Biomedical Engineeri	ng: Specialisation Manage	ement and Busines	s Administration: Elective (	Compulsory	
	Theoretical Mechanic	al Engineering: Specialisa	ation Bio- and Medi	cal Technology: Elective Co	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	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	g - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	63)	Seminar	2	3
Introduction to Waveguides, Antenn	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antenn	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	2
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
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	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	6			
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 a	and Business Administration: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artificial Organ			
	2.5ca.ca. Engineering. Specialisation Artificial Organ	.s and regenerative medicine. Elective	20pui30i y	

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

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

Course L1588: Development 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	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical
	knowledge is provided.
	1. Tribology
	2. Optical Methods
	3. Motion Analysis
	4. Pressure Distribution
	5. Strain Gauges
	6. Pre-clinical testing
	7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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	
<b>Examination Form</b>	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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

ourse L0001: Fluid Mechan		
Тур	2	
Hrs/wk		
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     Translate for signal if it is the a New ins States Founting.	
	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  Place Lead Discussion Field and the second sec	
	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, 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 / GV	
	Fachverlage GmbH, Wiesbaden, 2008.	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	<ol> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne GWV Fachverlage GmbH, Wiesbaden, 2009.</li> </ol>	
	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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	<ul> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Hydraulic systems and heat transfer</li> <li>Example: System with different subsystems</li> </ul>
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	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 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	2
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
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	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	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
_	Biomedical Engineering: Specialisation Medical Techn		pulsory	
	3 - 3 - 7 - 7 - 7 - 7 - 7 - 7 - 7 - 7 -			

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

Тур	Lecture	
Hrs/wk	3	
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		
Language		
	SoSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.	
	Topics:	
	- Fundamental properties and phenomena of electrical circuits	
	- Steady-state sinusoidal analysis of electrical circuits	
	- Fundamental properties and phenomena of electromagnetic fields and waves	
	- Steady-state sinusoidal description of electromagnetic fields and waves	
	- Useful microwave network parameters - Transmission lines and basic results from transmission line theory	
	- Plane wave propagation, superposition, reflection and refraction	
	- General theory of waveguides	
	- Most important types of waveguides and their properties	
	- Radiation and basic antenna parameters	
	- 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	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 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	
Cycle	SoSe
	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical knowledge is provided.  1. Tribology 2. Optical Methods 3. Motion Analysis 4. Pressure Distribution 5. Strain Gauges 6. Pre-clinical testing 7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen  White A.A., Panjabi M.M.: Clinical biomechanics of the spine  Nigg, B.: Biomechanics of the musculo-skeletal system  Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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

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	Dr. Gerd Huber, Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

Tom	Lecture				
Тур					
Hrs/wk					
СР					
Workload in Hours					
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. Prover LL Crundlagen der Einnhagen und Mahrnhagenströmungen Vorlag Cauerländer Aarau Frankfurt (M. 1071				
	<ol> <li>Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.</li> <li>Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.</li> </ol>				
	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, 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	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 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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				
<b>Educational Objectives</b>	After taking part successfully, students have re	eached the following learning results		
<b>Professional Competence</b>				
Skills	can be discussed in terms of decision probler world scenarios, students can summarize how formalism in static and dynamic settings. In a settings, with and with complete access to the solving (partially observable) Markov decision. Students can identify techniques for simultant desired states. Students can explain coordinate of equilibria, social choice functions, voting process of the social choice functions, voting process of the social choice functions and apply networks/dynamic Bayesian networks and an different sampling techniques for simplified and best action or policies for concrete settings. In	- '	For dealing with whedge represent procedures in sistudents can destinate the winder of	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				
•	Students are able to discuss their solutions to	problems with others. They communicate in Eng	glish	
4.4		No. of contract to the contract of		
Autonomy	Students are able of checking their understand	ang of complex concepts by solving varants of	concrete problem	15
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Consulta and the	6			
Credit points				
Course achievement	None			
Course achievement	None Written exam			
Course achievement	Written exam			
Course achievement Examination	Written exam			
Course achievement Examination Examination and	Written exam	e Engineering: Elective Compulsory		
Course achievement Examination Examination duration and scale	Written exam 90 minutes  Computer Science: Specialisation II: Intelligence	te Engineering: Elective Compulsory Decialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam 90 minutes  Computer Science: Specialisation II: Intelligence	pecialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation Intelligent System Mechatronics: Technical Complementary Course Mechatronics: Specialisation Intelligent System	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation II: Intelligenc International Management and Engineering: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation II: Intelligenc International Management and Engineering: Specialisation Intelligent System Mechatronics: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implant	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C ts and Endoprostheses: Elective Compulsory	Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Specialisation II: Intelligence International Management and Engineering: Specialisation Intelligent System Mechatronics: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implantation Biomedical Engineering: Specialisation Medical Engineering: Specialisation Medical	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C	Compulsory	

Tvn	Lecture				
	2				
-,	4				
_	Independent Study Time 92, Study Time in Lecture 28				
	Rainer Marrone				
	EN EN				
Cycle					
Content	WIGE				
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, produce rule, 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-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived).</li> <li>Probabilistic reasoning over time:         Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markotassumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation special cases: hidden Markov models, Kalman filters, Exact inferences and approximations</li> <li>Decision making under uncertainty:         Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs         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, Reve</li></ul>				
	Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externali 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, 1-11, 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 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 Vibration Theory (L0701)	Typ Hrs/wk CP Integrated Lecture 4 6				
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Calculus     Linear Algebra     Engineering Mechanics				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence  Knowledge  Skills	В				
SKIIS	<ul> <li>Students are able to denote methods of Vibration Theory and develop them further.</li> <li>Students are able to apply and expand methods of modeling and simulation for free, forced, self-excited and parametrized driven vibrations.</li> <li>Students are able to solve linear and nonlinear vibration problems.</li> </ul>				
Personal Competence Social Competence Autonomy	<ul> <li>Students can analyze vibration problems, work on them, and reach working results also in teams or groups.</li> <li>Students are able to document the results of vibration studies also in groups.</li> <li>Students are able to individually analyze and solve vibration problems.</li> <li>Students are able to approach individually research tasks in Vibration Theory.</li> </ul>				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	None				
Examination	Written exam				
Examination duration and	2 Hours				
scale					
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory				
Following Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory				

Course L0701: Vibration Theory		
Тур	Integrated Lecture	
Hrs/wk	4	
СР	6	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Lecturer	Prof. Norbert Hoffmann	
Language	DE/EN	
Cycle	WiSe	
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations	
	<ul> <li>Free vibration</li> <li>Self-excited vibration</li> <li>Parameter driven vibration</li> <li>Forced vibration</li> <li>Multi degree of freedom vibration</li> <li>Continuum vibration</li> <li>Irregular vibration</li> </ul>	
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen.	
	English - K. Magnus: Vibrations.	

Module M0808: Finite	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			
	None			
	Mechanics I (Statics, Mechanics of Materials) and Mechanics I (Statics, Mechanics of Materials)	anics II (Hydrostatics, Kinematics, Dyna	amics)	
	, , , , , , , , , , , , , , , , , , , ,			
Educational Objectives	After taking part successfully, students have reached the	ne following learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge regardi	ng the derivation of the finite eleme	ent method and	are able to give
	overview of the theoretical and methodical basis of the	mediod.		
Skills	The students are capable to handle engineering problessystem matrices, and solving the resulting system of each		ments, assemblin	g the correspondi
	Students can work in small groups on specific problems The students are able to independently solve challe Problems can be identified and the results are critically	nging computational problems and c	levelop own finit	e element routin
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement		ription		
	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Compulsory			
Following Curricula	Energy Systems: Core Qualification: Elective Compulsor	У		
	Aircraft Systems Engineering: Core Qualification: Elective	e Compulsory		
	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering: Specialisat	ion II. Product Development and Produ	iction: Elective Co	ompulsory
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants and En	doprostheses: Compulsory		
	Biomedical Engineering: Specialisation Management an		mpulsory	
	Biomedical Engineering: Specialisation Medical Technol		. ,	
	Biomedical Engineering: Specialisation Artificial Organs	•	•	
	Product Development, Materials and Production: Core C	•		
	Technomathematics: Specialisation III. Engineering Scie			
		, ,		
	Theoretical Mechanical Engineering: Core Qualification:	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	t Methods
Тур	Recitation Section (large)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0814: Techr	nology Management			
	lology Fluinagement			
Courses				
Title		Тур	Hrs/wk	СР
Technology Management (L0849) Technology Management Seminar	(1.0850)	Lecture Project-/problem-based Learning	3	3 3
	Prof. Cornelius Herstatt	. roject /problem basea zeaming	_	
Admission Requirements	Bachelor knowledge in business management			
Knowledge	bachelor knowledge in business management			
	After taking part successfully, students have reached the foll	owing learning results		
Professional Competence	The taking part succession, y state his have reached the for	og realist		
-	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies			
	Technology Strategies and Lifecycle Manageme     Technology Strategies and Lifecycle Manageme	nt (I/II)		
	Technology Intelligence and Planning  Technology Intelligence and			
	Technology Portfolio Management     Technology Portfolio Methodology			
	Technology Polition Methodology     Technology Acquisition and Exploitation			
	IP Management			
	Organizing Technology Development			
	Technology Organization & Management			
	Technology Funding & Controlling			
Skills	The course aims to:			
	Develop an understanding of the importance of Technol	ology Management - on a national a	c well ac inter	national level
	Equip students with an understanding of importa-			
	organizational and process-related aspects)			
	Foster a strategic orientation to problem-solving with	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. tech</li> </ul>	inology sourcing, maintenance and	exploitation)	
	Strengthen essential communication skills and a base	sic understanding of managerial, o	organizational	and financial issues
	concerning Technology-, Innovation- and R&D-manage	ement. Further topics to be discusse	d include:	
	<ul> <li>Basic concepts, models and tools, relevant to the man</li> </ul>	agement of technology, R&D and in	novation	
	Innovation as a process (steps, activities and results)			
Personal Competence				
Social Competence				
	Interact within a team     Paice awareness for glabablissues			
	Raise awareness for globabl issues			
Autonomy	Gain access to knowledge sources			
	Gain access to knowledge sources     Discuss recent research debates in the context of Tech	anology and Innovation Managemen	t	
	Develop presentation skills	mology and milovation managemen		
	Discussion of international cases in R&D-Management			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the	Global Innovation Management: Core Qualification: Compulso	ory		
Following Curricula	-		mpulsory	
3 ,	Mechanical Engineering and Management: Specialisation Man	•		
	Biomedical Engineering: Specialisation Artificial Organs and F		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	iness Administration: Compulsory		

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)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, mechanics and semicond	ductor technology		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able			
	<ul> <li>to present and to explain current fabrication to microsensors and microactuators, as well as the integ</li> </ul>		lly methods f	or the fabrication
	<ul> <li>to explain in details operation principles of micros</li> </ul>	sensors and microactuators and		
	to explain in details operation principles or illeres	consorts and this outcomes and		
	<ul> <li>to discuss the potential and limitation of microsys</li> </ul>	tems in application.		
Skills	Students are capable			
	<ul> <li>to analyze the feasibility of microsystems,</li> </ul>			
	to dridiyze the reasibility of finerosystems,			
	<ul> <li>to develop process flows for the fabrication of mid</li> </ul>	crostructures and		
	to apply them.			
	со арру спети.			
Personal Competence				
Social Competence				
	Students are able to plan and carry out experiments	s in groups, as well as present and repres	ent the resul	ts in front of othe
	These social skills are practiced both during the pre	paration phase, in which the groups work	out and pres	sent the theory, a
	during the follow-up phase, in which the groups prepa	re, document and present their practical ex	periences.	
Autonomy	The independence of the students is demanded and	promoted in that they have to transfer and	apply what	they have learned
	ever new boundary conditions. This requirement is co			
	the exam. Students are encouraged to work independ	dently by not being given a solution, but by	learning to v	work out the soluti
	step by step by asking specific questions. Students	learn to ask questions independently whe	n they are fa	ced with a proble
	They learn to independently break down problems into	o manageable sub-problems.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	96		
Credit points	6			
Course achievement		scription		
	Yes None Subject theoretical andSt	udierenden führen in Kleingruppen ein La	borpraktikum	durch. Jede Grup
	·	äsentiert und diskutiert die Theorie sowie d	lie Ergebniise	ihrer Labortätigke
	VO	r dem gesamten Kurs.		
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics	and Microsystems Technology: Elective Co	mpulsory	
Following Curricula	Electrical Engineering: Specialisation Medical Technol	ogy: Elective Compulsory		
	nternational Management and Engineering: Specialisa			
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techno			
	Biomedical Engineering: Specialisation Management a	ind Business Administration: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Artificial Orgar Microelectronics and Microsystems: Core Qualification		pulsory	

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

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

Module M0846: Contr	ol Systems Theory and Desig	n		
Courses				
Title Control Systems Theory and Design		<b>Typ</b> Lecture Recitation Section (small)	Hrs/wk 2 2	<b>CP</b> 4 2
Control Systems Theory and Design  Module Responsible		Recitation 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		
<b>Professional Competence</b>				
<i>Knowledge</i> Skills	<ul> <li>Students can explain how linear dynamic systems are represented as state space models; they can interpret the syster response to initial states or external excitation as trajectories in state space</li> <li>They can explain the system properties controllability and observability, and their relationship to state feedback and state state astimation, respectively</li> <li>They can explain the significance of a minimal realisation</li> <li>They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain the z-transform and its relationship with the Laplace Transform</li> <li>They can explain the experimental identification of ARX models of discrete-time systems</li> <li>They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem of the solved by solving a normal equation</li> <li>They can explain how a state space model can be constructed from a discrete-time impulse response</li> </ul> Students can transform transfer function models into state space models and vice versa <ul> <li>They can assess controllability and observability and construct minimal realisations</li> <li>They can design LQG controllers for multivariable plants</li> <li>They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate</li> <li>They can identify transfer function models and state space models of dynamic systems from experimental data</li> <li>They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox Simulink)</li> </ul>		e feedback and state  pance rejection  ification problem can  which is appropriate	
	Students can work in small groups on spec Students can obtain information from pro when solving given problems.	ific problems to arrive at joint solutions. vided sources (lecture notes, software docum	entation, experimer	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				
Course achievement	None			
	Written exam			
Examination duration and	120 min			
scale				
-	Electrical Engineering: Core Qualification: C	, ,		
Following Curricula	Energy Systems: Core Qualification: Electiv Aircraft Systems Engineering: Core Qualific			
	Computer Science in Engineering: Specialis 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 Mec Biomedical Engineering: Specialisation Mar	sation II. Engineering Science: Elective Compuls g: Specialisation II. Electrical Engineering: Electi g: Specialisation II. Mechatronics: Elective Comp Specialisation Mechatronics: Elective Compulso	ve Compulsory ulsory ry ve Compulsory ry	

<b>7</b>	Locture
	Lecture
Hrs/wk	
	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	Worner H. Locture Notes: Central Systems Theory and Design"
	Werner, H., Lecture Notes "Control Systems Theory and Design"     T. Kailath "Linear Systems" Proptice Hall 1990
	T. Kailath "Linear Systems", Prentice Hall, 1980  K. L. Actrom, P. Wittenmark, "Computer Controlled Systems", Prentice Hall, 1997.
	<ul> <li>K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997</li> <li>L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999</li> </ul>

Course L0657: Control 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
roduction Planning and Control (L		Lecture	2	2
roduction Planning and Control (L		Recitation Section (small)	1	1
xercise: The Digital Enterprise (LC		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements		. M		
	Fundamentals of Production and Qualit	ty Management		
Knowledge	AG and all the second second like all all all all all all all all all al	a haran and a hala bar faller for harantary and harantary		
	After taking part successfully, students have reached the following learning results			
Professional Competence	St. dayler and the street of the			
•	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and	applying models and methods from the module to indu	strial problems.	
Personal Competence				
•	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
	Independent Study Time 96, Study Tim	ne in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	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: Specialisation Production and Logistics: Elective Compulsory			
	Biomedical Engineering: Specialisation	Artificial Organs and Regenerative Medicine: Elective (	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation	Medical Technology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation	Management and Business Administration: Compulsor	у	
	·	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	iterprise
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Robert Rost
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	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>

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	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. Robert Rost	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses				
<b>Title</b> Continuum Mechanics (L1533)	Ту	<b>p</b> cture	Hrs/wk 2	<b>CP</b> 3
Continuum Mechanics (£1333)		citation Section (small)	2	3
Module Responsible				
Admission Requirements	·			
	Basics of mechanics as taught, e.g., in the modules Engineering M	lechanics I and Engineeri	ng Mechanics II a	at TUHH (forces an
Knowledge				
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following lo	earning results		
<b>Professional Competence</b>				
Knowledge	In this module, students learn the fundamental concepts of nonli			
	describe arbitrary deformations of continuous bodies (solid, liquid o			
	of the basic module Engineering Mechanics II (elastostatics), the lin		opic, iinear-eiasti	c material benavio
	small deformations, simple geometries) of which are successively el	illilliateu.		
	First, the students learn the necessary fundamentals of tensor calcu	lus. Based on this, the des	scription of the de	eformations / strair
	of arbitrarily deformable bodies is dealt with. The students learn the			
	a body and for formulating the balance equations for mass, mome			
	students know which constitutive assumptions have to be made for	modeling the material ber	navior of a mecha	inical body.
Skills	The students can set up balance laws and apply basics of deforma	ation theory to specific as	pects, both in ap	plied contexts as
	research contexts.			
Personal Competence				
Social Competence		ns of solid mechanics, to p	oresent them to s	specialists in writte
	form and to develop ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesse	s. They can independently	y and on their ow	n identify and solv
	problems in the area of continuum mechanics and acquire the know	ledge required to this end		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Compulsory			
Following Curricula				
	Mechatronics: Technical Complementary Course: Elective Compulsor		1	
	Biomedical Engineering: Specialisation Artificial Organs and Regener		ompulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses		ulsory	
	Biomedical Engineering: Specialisation Medical Technology and Cont Biomedical Engineering: Specialisation Management and Business A		-	
	Product Development, Materials and Production: Core Qualification:			
	Theoretical Mechanical Engineering: Core Qualification: Elective Con			
		-		

Course L1533: Continuum Me	nehanice.	
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Cycle	WiSe Continuum mechanics is a general theory to describe the effect of mechanical forces on continuous mechanical (both solid and fluid) bodies. An important part of continuum mechanics is the mathematical description of strains and stresses as well as the stress-strain response of continuous mechanical bodies. The lecture continuum mechanics builds on the foundations tought in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) the focus was by and large limited to small deformations of simple bodies under simple loading, the lecture continuum mechanics introduces a general mathematical framework to deal with arbitrarily shaped bodies under arbitrary loading undergoing very general kinds of deformations. This lecture focuses primarily on theoretical aspects of continuum mechanics but its content is key to numerous applications in modern engineering, for example, in production, automotive, and biomedical engineering. The lecture covers:  • Fundamentals of tensor calculus  • Transformation invariance  • Transformation invariance  • Transformation invariance  • Transformation of continuum  • Deformation of infinitesimal line, area and volume elements  • Material and spatial description  • Polar decomposition  • Objectivity  • Strain measures  • Time derivatives  • Partial / material time derivatives  • Dobjective time rates  • Strain and deformation rates  • Transport theorems  • Balance equations (global and local form)  • Balance of mass  • The stress state  • Surface traction vectors  • Cauchy's fundamental theorem  • Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)	
	Balance of energy     Balance of entropy     Clausius-Duhem inequality      Constitutive laws	
	<ul> <li>Constitutive assumptions</li> <li>Fluids</li> <li>Elastic solids</li> <li>Hyperelasticity</li> </ul>	
	<ul> <li>Material symmetry</li> <li>Elasto-plastic solids</li> <li>Analysis</li> <li>Initial-boundary value problems and their numerical solution</li> </ul>	
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer	

Course L1534: Continuum Mo	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	The exercise on Continuum Mechanics explains the theoretical content of the lecture on Continuum Mechanics by way of a series of specific example problems.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer

Courses				
itle		Тур	Hrs/wk	СР
Material Modeling (L1535) Material Modeling (L1536)		Lecture Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron	, , , , , , , , , , , , , , , , , , , ,		-
Admission Requirements	·			
Recommended Previous		Engineering Mechanics I and Engineer	ing Mechanics II	at TUHH (forces
Knowledge	moments, stress, linear strain, free-body principle, lir	near-elastic constitutive laws, strain ener	gy); basics of ma	thematics as tau
	e.g., in the modules Mathematics I and Mathematics	II at TUHH		
<b>Educational Objectives</b>	After taking part successfully, students have reached	I the following learning results		
Professional Competence				
Knowledge	The students understand the theoretical foundations			
	three-dimensional (linear) continuum mechanics. In t			-
	and its application in orthotropic, transversely isotr	· · · · · · · · · · · · · · · · · · ·		•
	compliance and how both can be characterized by an in the time and frequency domain using the concepts			
	the area of elasto-plasticity, the students know the			
	potential. Additionally, the know the concepts of i	. ,		
	plasticity as a specific model of elasto-plasticity.	, , , , , ,		
Skills	The students can independently identify and solve pr	roblems in the area of materials modeling	g and acquire the	knowledge to d
	This holds in particular for the area fo anisotropically	y elastic, viscoelastic and elasto-plastic	material behavio	r. In these areas,
	students can independently develop models for co	omplex material behavior. To this end,	they have the	ability to read
	understand relevant literature and identify the relevant	ant results reported there. Moreover, th	ey can implemen	nt models which
	developed or found in the literature in computational	al software (e.g., based on the finite ele	ment method) an	nd use it for prac
	calculations.			
Personal Competence				
Social Competence				
	to discuss challening problems of materials model		-	itify and ask cri
	questions in such discussions and to identify and disc	cuss potential caveats in models present	eu to them.	
Autonomy	The students have the ability to independently devel	op abstract models that allow them to cl	assify observed p	ohenomena withi
	more general abstract framework and to predict the	eir further evolution. Moreover, the stud	lents understand	the advantages
	also limitations of mathematical models and can thus	s independently decide when and to whi	ch extent they m	ake sense as a b
	for decisions.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	, ,			
Course achievement				
Examination	Written exam			
Examination duration and	60 min			
scale				
_	Materials Science: Specialisation Modeling: Elective C			
Following Curricula				
	Biomedical Engineering: Specialisation Artificial Orga	-	Compulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Techr	nology and Control Theory: Elective Com		
	Diamodical Engineering, Considiration Manageria	and Pusings Administration, Floating Ca	moulcori	
	Biomedical Engineering: Specialisation Management		ompulsory	
	Biomedical Engineering: Specialisation Management Product Development, Materials and Production: Core Theoretical Mechanical Engineering: Specialisation M	e Qualification: Elective Compulsory	ompulsory	

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	rse 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	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 d	esign new
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an ov	verview on
	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.	
·		
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	1 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. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Robert Meißner, Prof. Kaline Pagnan
	Furlan
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.

Courses				
		T	Here to the	CD.
<b>Title</b> Introduction to Biochemistry and M	Aplecular Riplogy (1.0386)	<b>Typ</b> Lecture	Hrs/wk	<b>CP</b> 3
		Lecture	2	3
•	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements				
Recommended Previous				
Knowledge		6 H . I . I . H		
	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	The students can			
	describe basic biomolecules;			
	explain how genetic information is coded in the DI	IA;		
	explain the connection between DNA and proteins			
CI III.	The state to the			
SKIIIS	The students can			
	recognize the importance of molecular parameters	for the course of a disease;		
	describe selected molecular-diagnostic procedures	;		
	explain the relevance of these procedures for some	e diseases		
Davagual Compotones				
Personal Competence		nd modicino on a tochnical lavel		
Social Competence	The students can participate in discussions in research a	nd medicine on a technical level.		
	Students will have an improved understanding of current medical problems (e.g. Corona pandemic)and will be able to explain			
	these issues to others.			
Autonomy	The students can develop an understanding of topics from	n the course, using technical liter	rature, by themselves	5.
	Students will be better equipped to recognize fake news	n the media regarding medical re	esearch tonics	
	Students will be better equipped to recognize take news	in the media regarding medicar is	escuren topics.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points				
Course achievement				
Course achievement				
Evamination				
Examination				
Examination duration and	60 minutes			
Examination duration and scale	60 minutes	or), Specialization Biomodi15-	oginooringi Compuls-	n.
Examination duration and scale Assignment for the	60 minutes  General Engineering Science (German program, 7 semes			
Examination duration and scale Assignment for the	60 minutes  General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 se			
Examination duration and scale Assignment for the	60 minutes  General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 se Compulsory	emester): Specialisation Mechar		
Examination duration and scale Assignment for the	60 minutes  General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 so Compulsory Electrical Engineering: Specialisation Medical Technology	emester): Specialisation Mechar : Elective Compulsory		
Examination duration and scale Assignment for the	60 minutes  General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 scompulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering	emester): Specialisation Mechan : Elective Compulsory ng: Compulsory	nical Engineering, F	ocus Biomechanio
Examination duration and scale Assignment for the	General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 se Compulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 semest	emester): Specialisation Mechar : Elective Compulsory ng: Compulsory er): Specialisation Biomedical Eng	nical Engineering, F	ocus Biomechani
Examination duration and scale Assignment for the	General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 semes Compulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 semest Mechanical Engineering: Specialisation Biomechanics: Co	emester): Specialisation Mechan : Elective Compulsory ng: Compulsory er): Specialisation Biomedical Eng mpulsory	nical Engineering, F	ocus Biomechani
Examination duration and scale Assignment for the	General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 semes Compulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 semest Mechanical Engineering: Specialisation Biomechanics: Co Biomedical Engineering: Specialisation Management and	emester): Specialisation Mechan : Elective Compulsory ng: Compulsory er): Specialisation Biomedical Eng mpulsory Business Administration: Elective	nical Engineering, F gineering: Compulsor e Compulsory	ocus Biomechani
Examination duration and scale Assignment for the	General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 semes Compulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 semest Mechanical Engineering: Specialisation Biomechanics: Co Biomedical Engineering: Specialisation Management and Biomedical Engineering: Specialisation Artificial Organs a	emester): Specialisation Mechan : Elective Compulsory ng: Compulsory er): Specialisation Biomedical Eng mpulsory Business Administration: Elective nd Regenerative Medicine: Elective	nical Engineering, F gineering: Compulsor e Compulsory ve Compulsory	ocus Biomechani
Examination duration and scale Assignment for the	General Engineering Science (German program, 7 semes General Engineering Science (German program, 7 semes Compulsory Electrical Engineering: Specialisation Medical Technology Engineering Science: Specialisation Biomedical Engineering General Engineering Science (English program, 7 semest Mechanical Engineering: Specialisation Biomechanics: Co Biomedical Engineering: Specialisation Management and	emester): Specialisation Mechan : Elective Compulsory ng: Compulsory er): Specialisation Biomedical Engangulsory Business Administration: Elective nd Regenerative Medicine: Elective ny and Control Theory: Elective C	nical Engineering, Formal Engineering: Compulsory  The Compulsory  The Compulsory  The Compulsory  The Compulsory  The Compulsory	ocus Biomechani

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

Module M1334: BIO II	: Biomaterials			
Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical technic	ques is recommended.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reach	ned the following learning results		
<b>Professional Competence</b>				
Knowledge	The students can describe the materials of the hur use.	man body and the materials being use	d in medical engineerir	ng, and their fields
Skills	The students can explain the advantages and disa	dvantages of different kinds of biomat	erials.	
Personal Competence				
Social Competence	The students are able to discuss issues related to	materials being present or being used	d for replacements with	student mates an
	the teachers.			
Autonomy	The students are able to acquire information on th	eir own. They can also judge the infor	mation 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: Specia	alisation II. Process Engineering and B	iotechnology: Elective (	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid	Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Or	gans and Regenerative Medicine: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation Implants ar			
	Biomedical Engineering: Specialisation Medical Tec	,		
	Biomedical Engineering: Specialisation Manageme			
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective	e 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				
Courses				
Title	Тур	Hrs/wk	СР	
Structure and Properties of Polymers (L0389) Processing and design with polymers (L1892)	Lecture Lecture	2	3 3	
Module Responsible Dr. Hans Wittich	Eccuse		3	
Admission Requirements None				
Recommended Previous Basics: chemistry / physics / material scie	nco			
Knowledge	nice			
Educational Objectives After taking part successfully, students ha	ave reached the following learning results			
Professional Competence	are reached the ronorming realiting results			
Knowledge Students can use the knowledge of plastic	cs and define the necessary testing and anal	ysis.		
They can explain the complex relationship	ps structure-property relationship and			
the interactions of chemical structure of t protection).	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environments).			
Skills Students are capable of				
- using standardized calculation method evaluate the different materials.	- using standardized calculation methods in a given context to mechanical properties (modulus, strength evaluate the different materials.			
- selecting appropriate solutions for mech	nanical recycling problems and sizing examp	le stiffness, corrosion re	sistance.	
Personal Competence				
Social Competence Students can				
- arrive at funded work results in heteroge	enius groups and document them			
arrive de landed work results in neteroga	emas groups and document them.			
- provide appropriate feedback and handl	e feedback on their own performance constr	uctively.		
Autonomy Students are able to				
- assess their own strengths and weaknes	sses.			
- assess their own state of learning in spe	on this basis.			
- assess possible consequences of their p	- assess possible consequences of their professional activity.			
Workload in Hours Independent Study Time 124, Study Time	in Lecture 56			
Credit points 6				
Course achievement None				
Examination Written exam				
Examination duration and 180 min				
scale				
Assignment for the Materials Science: Specialisation Engineer	ring Materials: Elective Compulsory			
Following Curricula Biomedical Engineering: Specialisation Im	plants and Endoprostheses: Compulsory			
3 3 1	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
	anagement and Business Administration: Ele			
	edical Technology and Control Theory: Election			
	uction: Specialisation Production: Elective Co			
·	uction: Specialisation Materials: Elective Con uction: Specialisation Product Development:			
·	iaction: Specialisation Product Development:			

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		

Carrie					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (I 166	1)	Seminar Seminar	2	3 3
Module Responsible		•,			
Admission Requirements	None				
Recommended Previous					
Knowledge	None				
Educational Objectives	After taking part suc	cessfully, students have re	ached the following learning results		
Professional Competence	3 7 3 7 3 3 3	,,			
	e After successful completion of the module students will be able to describe the basic methods of regenerative				tive medicine and
, and the second			nethods of tissue engineering. They are		
	the cultivation of animal and human cells.				
	The students are		Ti Fii		
		of the discussed topics.	s of Tissue Engineering and regener	rative medicine and ca	in explain the ba
	durierrying principles	of the discussed topics.			
Skills	After successful com	pletion of the module stud	ents 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 present their work results in the form of presentations     able to carry out basic cell culture methods and the corresponding analysis independently				
			earch topics for Tissue Engineering and		
Personal Competence					
Social Competence		work together as a team v	vith 2-4 students to solve given tasks a	nd discuss their results	in the plenary and
	defend them.				
	Students are able to reflect their work orally and discuss it with other students and teachers.				
Autonomy					
	After completion of this module, participants will be able to solve a technica				approx. 2-4 perso
	independently including a presentation of the results.				
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	_		and Endoprostheses: Elective Compul	•	
Following Curricula					
	_	• .	ment and Business Administration: Elec		
	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				
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			

Implants and Fracture Healing		
Typ         Hrs/wk         CP           376)         Lecture         2         3		
Prof. Michael Morlock		
None		
It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".		
After taking part successfully, students have reached the following learning results		
The students can describe the different ways how bones heal, and the requirements for their existence.		
The students can name different treatments for the spine and hollow bones under given fracture morphologies.		
The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.		
The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
Independent Study Time 62, Study Time in Lecture 28		
3		
None		
Written exam		
90 min		
General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic		
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		
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	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language			
Cycle	Topics to be covered include:		
	Introduction (history, definitions, background importance)		
	Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)		
	3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)		
	3.1 The spine in its entirety		
	3.2 Cervical spine		
	3.3 Thoracic spine		
	3.4 Lumbar spine		
	3.5 Injuries and diseases		
	4. Pelvis (anatomy, biomechanics, fracture treatment)		
	5 Fracture Healing		
	5.1 Basics and biology of fracture repair		
	5.2 Clinical principals and terminology of fracture treatment		
	5.3 Biomechanics of fracture treatment		
	5.3.1 Screws		
	5.3.2 Plates		
	5.3.3 Nails		
	5.3.4 External fixation devices		
	5.3.5 Spine implants		
	6.0 New Implants		
Literature	Cochran V.B.: Orthopädische Biomechanik		
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics		
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine		
	Nigg, B.: Biomechanics of the musculo-skeletal system		
	Schiebler T.H., Schmidt W.: Anatomie		
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat		

Module M0634: Introd	duction into Me	dical Technology	and Systems		
Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)			Lecture	2	3
Introduction into Medical Technolog			Project Seminar	2	2
Introduction into Medical Technolog	I		Recitation Section (large	2) 1	1
Module Responsible		efer			
Admission Requirements					
Recommended Previous					
Knowledge	principles of stochast principles of program				
	principles of program	ming, K/Matiab			
<b>Educational Objectives</b>	After taking part succ	essfully, students have rea	sched the following learning results		
Professional Competence					
Knowledge			al technology, including imaging system		
	information systems.	They are able to give an o	verview of regulatory affairs and standa	rds in medical techno	logy.
Skills	The students are able	e to evaluate systems and	medical devices in the context of clinica	l applications.	
		,			
Personal Competence					
Social Competence		·	nnology as a project, and define tasks th	•	
	The students can criti	ically reflect on the results	of other groups and make constructive	suggestions for impro	vement.
4	The shorteness of the			The second selection live	
Autonomy		sess their level of knowle t them in an appropriate m	edge and document their work results	. They can critically	evaluate the results
	acilieved and present	t trieffi iii aii appropriate iii	anner.		
Workload in Hours	Independent Study Ti	me 110, Study Time in Led	ture 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination duration and scale	90 minutes				
Assignment for the	General Engineering	Science (German program	7 semester): Specialisation Biomedical	Engineering: Compute	eory.
Following Curricula			s and Engineering Science: Elective Cor		SOT y
. ceming carricula		lisation II. Application: Elec			
		ualification: Elective Comp			
		: Core Qualification: Electi:			
	Engineering Science:	Specialisation Biomedical	Engineering: Compulsory		
	General Engineering	Science (English program,	7 semester): Specialisation Biomedical I	Engineering: Compulso	ory
	Computer Science in	Engineering: Specialisation	II. Mathematics & Engineering Science	Elective Compulsory	
	Biomedical Engineering	ng: Specialisation Artificial	Organs and Regenerative Medicine: Ele	ctive Compulsory	
	_		and Endoprostheses: Elective Compulse	•	
	_		Fechnology and Control Theory: Elective		
	_		nent and Business Administration: Elect	ive Compulsory	
	Technomathematics:	Specialisation III. Engineer	ing Science: Elective Compulsory		

Course L0342: Introduction into Medical Technology and Systems				
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28			
Lecturer	of. Alexander Schlaefer			
Language	DE			
Cycle	SoSe			
Content	- imaging systems			
	- computer aided surgery			
	- medical sensor systems			
	- medical information systems			
	- regulatory affairs			
	standard in medical technology			
	he students will work in groups to apply the methods introduced during the lecture using problem based learning.			
Literature	Bernhard Priem, "Visual Computing for Medicine", 2014			
	Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097)			
	Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015			
	Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014			
	H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687)			
	Wolfgang Drexler, "Optical Coherence Tomography", 2008			
	Kramme, "Medizintechnik", 2011			
	Thorsten M. Buzug, "Computed Tomography", 2008			
	Otmar Scherzer, "Handbook of Mathematical Methods in Imaging", 2015			
	Weishaupt, "Wie funktioniert MRI?", 2014			
	Paul Suetens, "Fundamentals of Medical Imaging", 2009			
	Vorlesungsunterlagen			

Course L0343: Introduction i	Course L0343: Introduction into Medical Technology and Systems			
Тур	ect Seminar			
Hrs/wk	2			
СР	2			
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28			
Lecturer	of. Alexander Schlaefer			
Language				
Cycle	oSe			
Content	ee interlocking course			
Literature	See interlocking course			

Course L1876: Introduction i	ourse L1876: Introduction into Medical Technology and Systems			
Тур	citation Section (large)			
Hrs/wk	1			
СР				
Workload in Hours	dependent Study Time 16, Study Time in Lecture 14			
Lecturer	f. Alexander Schlaefer			
Language				
Cycle	SoSe			
Content	ee interlocking course			
Literature	See interlocking course			

Courses				
Title Robotics and Navigation in Medicine (L0335) Robotics and Navigation in Medicine (L0338)		Typ Lecture Project Seminar	Hrs/wk 2 2	<b>CP</b> 3 2
Robotics and Navigation in Medicir		Recitation Section (small)	1	1
•	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	<ul> <li>principles of math (algebra, analys</li> <li>principles of programming, e.g., in</li> <li>solid R or Matlab skills</li> </ul>			
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge		d tracking systems in clinical contexts and illusinespect to collision detection and safety and research		
Skills	The students are able to design and evalu	uate navigation systems and robotic systems for n	nedical applications	i.
Personal Competence Social Competence	The students are able to grasp practical	tasks in groups, develop solution strategies ind	ependently, define	work processes ar
	work on them collaboratively.  The students are able to collaboratively organize their work processes and software solutions using virtual communication ar software management tools.  The students can critically reflect on the results of other groups, make constructive suggestions for improvement, and als incorporate them into their own work.			
Autonomy	The students can assess their level of knowledge and independently control their learning processes on this basis as well as document their work results. They can critically evaluate the results achieved and present them in an appropriate argumentative manner to the other groups.			
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70		
Credit points				
Course achievement	Compulsory Bonus Form Yes 10 % Written elaboratio Yes 10 % Presentation	<b>Description</b> N		
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation II: Intell	igence Engineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Med	lical Technology: Elective Compulsory		
	International Management and Engineering	ng: Specialisation II. Electrical Engineering: Electivng: Specialisation II. Process Engineering and Bioto ystems and Robotics: Elective Compulsory		Compulsory
		tificial Organs and Regenerative Medicine: Electiv	e Compulsory	
		plants and Endoprostheses: Elective Compulsory	c compaisory	
		edical Technology and Control Theory: Elective Co	mpulsorv	
		anagement and Business Administration: Elective		
		luction: Specialisation Product Development: Elect		
	· ·	luction: Specialisation Production: Elective Compu		
	·			
	Froduct Development, Materials and Frod	luction: Specialisation Materials: Elective Compuls	ory	

Course L0335: Robotics and Navigation in Medicine				
Тур	Lecture			
Hrs/wk				
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	ect Seminar			
Hrs/wk	2			
СР				
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28			
Lecturer	of. Alexander Schlaefer			
Language	V			
Cycle	SoSe			
Content	ee interlocking course			
Literature	See interlocking course			

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

Module M0752: Nonlii	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
-				
Recommended Previous				
Knowledge	Calculus			
	Linear Algebra			
	Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached t	the following learning results		
Professional Competence				
Knowledge				
	Students are able to reflect existing terms and	concepts in Nonlinear Dynamics and	to develop and res	earch new terms and
	concepts.	de ef es edeline and enclusis for earli		<b>.</b>
	Students are able to denote and expand method	us of modeling and analysis for nonli	near dynamicai sys	tems.
Skills	Charles and the bound of the control of	d a company of New Property		
	Students are able to apply existing methods and	•		
	Students are able to develop novel methods and	a procedures for nonlinear dynamica	i systems.	
Personal Competence				
Social Competence	Challest and the control of the Cont			
	<ul> <li>Students can analyze problems of nonlinear dyr</li> <li>Students can achieve solution procedures for pr</li> </ul>	- '	ome also in groups	
	Students can achieve solution procedures for pr	oblems of nonlinear dynamical syste	ins also in groups.	
Autonomy	Students are able to approach given research to	acks on the basis of given methods in	adividually	
	Students are able to approach given research to     Students are able to identify and follow up nove	-	idividually.	
	- Students are usic to identify and follow up hove	research tusks by themserves.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
_	Aircraft Systems Engineering: Core Qualification: Elect			
Following Curricula		·	-	
	Mechanical Engineering and Management: Specialisati	•	ry	
	Mechatronics: Specialisation System Design: Elective (			
	Mechatronics: Specialisation Intelligent Systems and R		o Compulsory	
	Biomedical Engineering: Specialisation Artificial Organ Biomedical Engineering: Specialisation Implants and E	•	e compuisory	
	Biomedical Engineering: Specialisation Implants and E Biomedical Engineering: Specialisation Medical Techno		mnulsory	
	Biomedical Engineering: Specialisation Management a	•		
	Product Development, Materials and Production: Core		compaisory	
	Theoretical Mechanical Engineering: Core Qualification			

urse 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
	One dimensional problems  Linear Stability  Local Bifurcations  Synchronisation  Two dimensional problems  Limit Cycles  Global Bifurcations  Chaos  Lorenz Equations  Fractals and Strange Attractors  Predictability and Horizons
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.

Courses				
Γitle		Тур	Hrs/wk	СР
Semiconductor Technology (L0722) Semiconductor Technology (L0723)		Lecture Practical Course	4 2	4 2
Module Responsible	Prof. Hoc Khiem Trieu	Tractical coarse		
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, material science	and semiconductor devices		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have r	eached the following learning results		
<b>Professional Competence</b>				
Knowledge				
	Students are able			
	to describe and to explain surrent fabricat	tion to shair ups for Si and CaAs substratos		
	to describe and to explain current labrical	tion techniques for Si and GaAs substrates,		
		brication processes, process flows and t	the impact thereof or	n the fabrication
	semiconductor devices and integrated circuits	and		
	to present integrated process flows.			
Skills				
	Students are capable			
	to analyze the impact of process paramet	ers on the processing results.		
		e.s o and processing results,		
	to select and to evaluate processes and			
	• to develop process flows for the fabrication	n of semiconductor devices.		
Personal Competence				
Social Competence				
	Students are able to plan and carry out expe	3 1 .	·	
	These social skills are practiced both during			sent the theory, ar
	during the follow-up phase, in which the group	os prepare, document and present their pra	ictical experiences.	
Autonomy	The independence of the students is demand	ed and promoted in that they have to trar	nsfer and apply what t	they have learned
,	ever new boundary conditions. This requireme			
	the exam. Students are encouraged to work i	ndependently by not being given a solutio	n, but by learning to v	vork out the solution
	step by step by asking specific questions. St		ntly when they are fa	ced with a probler
Wadded in Herre	They learn to independently break down probl			
Workload in Hours Credit points	Independent Study Time 96, Study Time in Le	cture o4		
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelec	ctronics and Microsystems Technology: Ele	ctive Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Artificia			
	Biomedical Engineering: Specialisation Implan	·	•	
	Biomedical Engineering: Specialisation Medica	I Technology and Control Theory: Flective	Compulsory	
	Biomedical Engineering: Specialisation Manag			

Hrs/wk 4  CP 4  Workload in Hours Independent Study Time 64, Study Time in Lecture 56  Lecturer Prof. Moc Khiem Trieu  Language   DE/EN    Cycle   SoSe    Content   Introduction (historical view and trends in microelectronics)    Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)    Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone programment of the process flow, specification, SOI)    Fabrication processes    Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profit order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation annealing and equipment)    Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxid GaAs)    Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques (APCVO, LPCVO, deposition or metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high evaporation, sputtering)    Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff techni electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography beam lithography. X-ray lithography. EVV lithography, ion beam lithography wet chemical etching: isotra anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)    Process integration (CMO5 process, bipolar proc
Workload in Hours
Lecturer   Prof. Hoc Khiem Trieu
Lacturer Language DE/EN Cycle SoSe  Content  • Introduction (historical view and trends in microelectronics) • Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone p • Wafer fabrication (process flow, specification, SOI) • Fabrication processes  • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profil order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation annealing and equipment)  • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation; reactions, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxi GaAs)  • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction temperature dependence and equipment; epitaxy; gas phase, liquid phase, molecular beam epitaxy; CVD techniques (type) and LECVD; basics of plasma, equipment, PVD techniques: high evaporation, sputtering)  • Structuring techniques (subtractive methods, photolithography; resist properties, printing techniques: contact, j and projection printing, resolution: excimer laser light source, immersion lithography and phase shift lithography beam ilthography. X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotranisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced 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 wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Cycle  Content  Introduction (historical view and trends in microelectronics)  Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)  Crystal fabrication (crystal pulling for Si and GAS: impurities, purification, Czochralski , Bridgeman and float zone p. Wafer fabrication (process flow, specification, SOI)  Fabrication processes  Deping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profil order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation annealing and equipment)  Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation; reactions, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxid GaAs)  Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction temperature dependence and equipment; epitaxy; gas phase, liquid phase, molecular beam epitaxy; CVD techniques: high evaporation, sputtering)  Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technic electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, beam lithography. X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotroplation in 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 wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Content  Introduction (historical view and trends in microelectronics)  Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)  Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone per deformance of the process flow, specification, SOI)  Fabrication processes  Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profil order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation annealing and equipment)  Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation; reactions, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidadas)  Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD tec APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high evaporation, sputtering)  Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, pand projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technic electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography beam lithography. X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotra anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced 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 wire bonding, TAB and flip chip, wafer level package, 3D
<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 p</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 profil order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxi GaAs)</li> <li>Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy: CVD tec APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high evaporation, sputtering)</li> <li>Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff techniques/croplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, beam lithography, X-ray lithography, EUV lithography, ion beam lithography and phase shift lithography beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotra anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced backsputtering, ion milling, chemical dry etching, Rie, sidewall passivation)</li> <li>Process</li></ul>
and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technical electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced 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 wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical wire 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
H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Ve
K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin

Course L0723: Semiconducto	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	

P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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 tricoly and design			
Educational Objectives	After taking part successfully, students have rea	ched 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	ents for different tasks in humanoid r	photics	
	Stadenies rearn to appry basic control cont			
G1.111				
Skills	Students acquire knowledge about select.	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		
Dorgonal Compatones				
Personal Competence Social Competence				
30Clar Competence	<ul> <li>Students are capable of developing soluti</li> </ul>	ons in interdisciplinary teams and pre	sent them	
	<ul> <li>They are able to provide appropriate feed</li> </ul>	back and handle constructive criticisn	n of their own results	
Autonomy				
riaconomy	<ul> <li>Students evaluate advantages and draw</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	ire 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 Managen			
	Theoretical Mechanical Engineering: Specialisati	on Robotics and Computer Science: El	ective Compulsory	

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

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	Charles Land (for			
Knowledge	Classical control (frequency res     State space methods	ponse, root locus)		
	Discrete-time systems			
	Linear algebra, singular value d	ecomposition		
	Basic knowledge about stochast			
	-	•		
Educational Objectives	After taking part successfully, students	s have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the gene	ral framework of the prediction error method a	and its application to a	variety of linear and
	nonlinear model structures			
	They can explain how multilaye	r perceptron networks are used to model nonline	ear dynamics	
	They can explain how an approx	ximate predictive control scheme can be based o	on neural network model	S
	They can explain the idea of sul	bspace identification and its relation to Kalman r	ealisation theory	
Skills				
Skins		ing the predicition error method to the experir	mental identification of	inear and nonlinea
	models for dynamic systems			
		ng a nonlinear predictive control scheme based		
		bspace algorithms to the experimental identification		•
	• They can do the above using sta	andard software tools (including the Matlab Syst	em identification rootbo	K)
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	rmation in sources provided (lecture notes, litera	ature software documer	ntation) and use it to
riaterioniny	solve given problems.	a.a soarees provided (rectare notes, men	acare, soremare accarrier	itation, and about to
Workload in Hours	, , , , , , , , , , , , , , , , , , , ,	ne in Lecture 28		
Credit points				
Course achievement	None			
Examination				
Examination duration and	30 min			
scale				
_		Control and Power Systems Engineering: Elective	Compulsory	
Following Curricula	,	t Systems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System D	resign: Elective Compulsory n Artificial Organs and Regenerative Medicine: Ele	ective Compulsory	
		i Artificial Organs and Regenerative Medicine: Eli i Implants and Endoprostheses: Elective Compuls	, ,	
		n Medical Technology and Control Theory: Compu		
		Management and Business Administration: Elec		
	Theoretical Mechanical Engineering: C		,,	
		. ,		

Course L0660: Linear and No	onlinear 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>

viodule MO840: 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				
Admission Requirements	None			
Recommended Previous Knowledge	Classical control (frequency response, root lo	ocus)		
Kilowieuge	State space methods			
	<ul> <li>Linear algebra, singular value decomposition</li> </ul>	ו		
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence		3		
Knowledge				
	Students can explain the significance of the			
	They can explain the duality between optimal     They can explain how the U2 and U infinite	·		h
	<ul> <li>They can explain how the H2 and H-infinity r</li> <li>They can explain how an LQG design problet</li> </ul>			
	They can explain how model uncertainty ca	· ·		
	They can explain how - based on the small			
	an uncertain plant.	g	,	p
	They understand how analysis and synthesis	conditions on feedback loops can be repr	esented as linear	matrix inequalitie
Clálla				
Skills	<ul> <li>Students are capable of designing and tunin</li> </ul>	g LQG controllers for multivariable plant m	iodels.	
	<ul> <li>They are capable of representing a H2 or H-</li> </ul>	infinity design problem in the form of a ge	neralized plant, a	nd of using standa
	software tools for solving it.			
	<ul> <li>They are capable of translating time and fr</li> </ul>	equency domain specifications for control	loops into const	raints on closed-lo
	sensitivity functions, and of carrying out a m			
	They are capable of constructing an LFT up	ncertainty model for an uncertain system	i, and of designir	ig a mixed-object
	robust controller.	d combosis conditions as linear matrix ins	auglities (LMI)	nd of using stands
	<ul> <li>They are capable of formulating analysis an LMI-solvers for solving them.</li> </ul>	a synthesis conditions as linear matrix me	equalities (LMI), a	na or using standa
	They can carry out all of the above using sta	andard software tools (Matlab robust contro	ol toolbox).	
Personal Competence				
	Students can work in small groups on specific prob			
Autonomy	Students are able to find required information in so	ources provided (lecture notes, literature,	software docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lectur	20.56		
Credit points	6	e 30		
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Control and P	, , , ,	ulsory	
Following Curricula	Energy Systems: Core Qualification: Elective Comp Aircraft Systems Engineering: Core Qualification: El	•		
	Mechatronics: Specialisation Intelligent Systems an	· •		
	Mechatronics: Specialisation System Design: Elective	, ,		
	Biomedical Engineering: Specialisation Artificial Org		Compulsory	
	Biomedical Engineering: Specialisation Implants an	•	,	
	Biomedical Engineering: Specialisation Medical Tec		pulsory	
	Biomedical Engineering: Specialisation Managemer	nt and Business Administration: Elective Co	ompulsory	
	Product Development, Materials and Production: Sp	pecialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Production: Sp	pecialisation Production: Elective Compulso	ory	
	Product Development, Materials and Production: Sp	pecialisation Materials: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Core Qualifica	tion: 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	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 N	larketing)		
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				
Knowledge	Module International Business     Basic understanding of business administration	principles (strategic planning decision	on theory pro	iect management
	international business)	principles (strategic planning, decision	on theory, pre	jeet management,
	Bachelor-level Marketing Knowledge (Marketing Ins.)	truments, Market and Competitor Strat	egies, Basics of	Buying Behavior)
	Unerstanding the differences beweetn B2B and B2G			
	Understanding of the importance of managing inno	vation in global industrial markets		
	Good English proficiency; presentation skills			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innovation     Approaches for applying the current market cituate			
	<ul> <li>Approaches for analyzing the current market situat</li> <li>The gathering of information about future custome</li> </ul>			
	Concepts and approaches to integrate lead users a		development r	processes
	Approaches and tools for ensuring customer-oriental			
	Marketing mix elements that take into considerati			
	services			
	Pricing methods for new products and services			
	The organization of complex sales forces and person			
	Communication concepts and instruments for new	oroducts and services		
Skills	Based on the acquired knowledge students will be able to	:		
	Design and to evaluate decisions regarding market	ing and innovation strategies		
	Analyze markets by applying market and technolog	y portfolios		
	Conduct forecasts and develop compelling scenario			
	Translate customer needs into concepts, prototype		fully apply adva	anced methods for
	customer-oriented product and service developmen			
	Use adequate methods to foster efficient diffusion (     Choose suitable pricing strategies and communicate)			
	Make strategic sales decisions for products and ser			
	Apply methods of sales force management (i.e. cus			
Personal Competence				
Social Competence	The students will be able to			
	have fruitful discussions and exchange arguments			
	develop original results in a group			
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
Autonomy	The students will be able to			
	Acquire knowledge independently in the specific co	ntext and to map this knowledge on ot	her new comple	ex problem fields.
	Consider proposed business actions in the field of r	narketing and reflect on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and		ation		
scale			<u> </u>	
Assignment for the	1	•		
Following Curricula	International Management and Engineering: Specialisation Mechanical Engineering and Management: Specialisation		приіѕогу	
	Biomedical Engineering and Management: Specialisation  Biomedical Engineering: Specialisation Artificial Organs ar		npulsorv	
	Biomedical Engineering: Specialisation Implants and Endo		,,	
	Biomedical Engineering: Specialisation Medical Technolog		sory	
	Biomedical Engineering: Specialisation Management and I			

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

Module Mosss: Blopr	ocess Engineering - Fundament	ais		
Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame	ntals (L0841)	Lecture	2	3
Bioprocess Engineering- Fundamer	ntals (L0842)	Recitation Section (large)	2	1
Bioprocess Engineering - Fundame	ntal Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
<b>Recommended Previous</b>	module "organic chemistry", module "fundam	entals for process engineering"		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have r	eached the following learning results		
<b>Professional Competence</b>				
Knowledge	Students are able to describe the basic conce	pts of bioprocess engineering. They are able t	o classify different	t types of kinetics
	enzymes and microorganisms, as well as to	o differentiate different types of inhibition.	The parameters o	of stoichiometry a
	rheology can be named and mass transport	processes in bioreactors can be explained.	The students are	e capable to expl
	fundamental bioprocess management, steriliz	ation technology and downstream processing i	n detail.	
Skills	After successful completion of this module, sto	udents should be able to		
	describe different kinetic approaches for	or growth and substrate-uptake and to calculat	e the correspondir	ng narameters
		energy generation, regeneration of redox equ		
	fermentation process	thergy generation, regeneration of redox equ	iivaiciits and gro	wen minibilion on t
	· ·	iometry and to set up / solve metabolic flux eq	uations	
		· · ·		well as microaerob
	<ul> <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> </ul>			
	to explore new knowledge resources and to apply the newly gained contents			
	identify scientific problems with concrete industrial use and to formulate solutions.      to decrease and discuss their areas decreases will be appropriately a constitution of the constitutions.			
	to document and discuss their procedures as well as results in a scientific manner			
Personal Competence		har title a stille to delicate to de stanta a selfacion		
Social Competence	After completion of this module participants s			
	take position to their own opinions and increas	se their capacity for teamwork in engineering a	and scientific envii	ronments.
Autonomy	After completion of this module participants v	vill be able to solve a technical problem in a t	eam independentl	y by organizing th
	workflow and to present their results in a plenum.			
Waddaad in Harris	Ladara and ant Charles Time a OC Charles Time a in La	-h 0.4		
	Independent Study Time 96, Study Time in Le	cture 84		
Credit points		Description		
Course achievement	Yes 5 % Subject theoretical	<b>Description</b> and		
	practical work	dild		
Examination	,			
Examination duration and	90 min			
scale	30 11111			
Scale				
Assignment for the	Bioprocess Engineering: Core Qualification: Co	ompulsory		
Following Curricula	Green Technologies: Energy, Water, Climate:	Specialisation Bioresource Technology: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Artifici	al Organs and Regenerative Medicine: Compul	sory	
	Biomedical Engineering: Specialisation Implan	ts and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medica	l Technology and Control Theory: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Manag	ement and Business Administration: Elective C	ompulsory	
	Technomathematics: Specialisation III. Engine	ering Science: Elective Compulsory		
	Process Engineering: Core Qualification: Comp	pulsory		

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		
Language	DE		
Cycle	SoSe		
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out.  The students document their experiments and results in a protocol.		
Literature	Skript		

Module M1143: Applie	ed Design Methodology in Mechatroni	cs		
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 compu	iter-sciences		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product desi	gn considering targeted application of sp	ecific product	design techniques
Skills	Creative handling of processes used for scientific prepa	ration and formulation of complex produc	t design prob	olems / Application of
	various product design techniques following theoretical	·	,	
		·		
Personal Competence				
Social Competence	Students will solve and execute technical-scientific to	asks from an industrial context in small	design-team	s with application of
	common, creative methodologies.			
Autonomy	Students are enabled to optimize the design and development process according to the target and topic of the design			
	Students are educated to operate in a development tea	m		
	Students learn about the right application of creative m	ethods in engineering.		
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: Specialisat	ion II. Product Development and Production	n: Elective C	ompulsory
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation	n Product Development and Production: E	lective Comp	ulsory
	Mechatronics: Specialisation System Design: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and En	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation Prod	luct Development 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 Design Methodology in Mechatronics		
Тур	oject-/problem-based Learning	
Hrs/wk		
СР		
Workload in Hours	dependent Study Time 78, Study Time in Lecture 42	
Lecturer	rof. Thorsten Kern	
Language	EN	
Cycle	SoSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M1277: MED	l: 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	Students can listen to the lectures without any prior knowledge. Basic school knowledge of biology, chemistry / biochemis		
Knowledge	physics and Latin can be useful.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
	The lectures are about microscopic anatomy, describing the microscopic structure of tissues and organs, and about macrosc anatomy which is about organs and organ systems. The lectures also contain an introduction to cell biology, human development to the central nervous system. The fundamentals of radiologic imaging are described as well, using projectional x-ray cross-sectional images. The Latin terms are introduced.  At the end of the lecture series the students are able to describe the microscopic as well as the macroscopic assembly functions of the human body. The Latin terms are the prerequisite to understand medical literature. This knowledge is needed.		
	functions of the human body. The Latin terms are the prerequisite to understand medical literature. This knowledge is needed understand und further develop medical devices.  These insights in human anatomy are the fundamentals to explain the role of structure and function for the development common diseases and their impact on the human body.		
Personal Competence			
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level. The Latin te are prerequisite for communication with physicians on a professional level.		
Autonomy	The lectures are an introduction to the basics of anatomy and should encourage students to improve their knowledge themselves. Advice is given as to which further literature is suitable for this purpose. Likewise, the lecture series encourastudents to recognize and think critically about biomedical problems.		
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 Biomechan		
	Compulsory		
	Data Science: Specialisation II. Application: Elective 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 L0384: Introduction t	o Anatomy	
Тур	Lecture	
Hrs/wk	2	
СР	3	
		Time 62, Study Time in Lecture 28
	Prof. Tobias Lange	
Language		
Cycle		
Content	General Anatomy	
	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
1:4	Adolf Follow/Mi-b	J Cabillaka Dar Körner des Manschen 17 Auflage Thioma Verlag Chuttaget 2016
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

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	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	<b>Therapy</b> 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 90 minutes
scale	
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  Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0383: Introduction t	to Radiology and Radiation Therapy
Тур	Lecture
Hrs/wk	2
СР	3
	Independent Study Time 62, Study Time in Lecture 28
Lecturer	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 M1280: MED I	II: Introduction to Physiology
Courses	
Title	Typ Hrs/wk CP
Introduction to Physiology (L0385)	Lecture 2 3
Module Responsible	Dr. Roger Zimmermann
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe the basics of the energy metabolism;
	<ul> <li>describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.</li> </ul>
G	
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, developmen
Davisanal Compatones	of forces and vital functions) and relate them to similar technical systems.
Personal Competence	The students can conduct discussions in research and medicine on a technical level.
Social Competence	The students can find solutions to problems in the field of physiology, both analytical and metrological.
	The state has can mile solutions to prosterior in the field of physiology) social and field of solutions
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, b
	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	
•	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics
	Compulsory  Data Sciences Specialization Medicines Compulsors
	Data Science: Specialisation Medicine: Compulsory  Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering: Specialisation Medical Technology: Elective Compulsory  Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0385: Introduction 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 M1335: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techni	ques is recommended.		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds of artifi	cial limbs.		
Cleille	The students can explain the advantages and disa	dvantages of different kinds of ande	prothogog	
SKIIIS	The students can explain the advantages and disa	davantages of different kinds of endo	protneses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to	endoprothese with student mates an	nd the teachers.	
Autonomy	The students are able to acquire information on th	air awa. Thay san also judgo the infe	armatian with respect to	ita aradibilitu
Autonomy	The students are able to acquire information on the	ien own. They can also judge the init	ormation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture	e 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Speci	alisation II. Process Engineering and	Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid	Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial O	gans and Regenerative Medicine: Ele	ective Compulsory	
	Biomedical Engineering: Specialisation Implants a	nd Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical Te	chnology and Control Theory: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation Manageme	nt and Business Administration: Elec	tive Compulsory	
	Orientation Studies: Core Qualification: Elective Co	ompulsory		
	Theoretical Mechanical Engineering: Specialisation	n Bio- and Medical Technology: Electi	ve Compulsory	

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

Module M0845: Feedl	oack Control in Medical Tech	inology		
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 h	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.			
	Internal control loops of the human boo example in for anesthesia control.	dy will be discussed in the same way like the	design of external clo	osed loop system fo
	The handling of PID controllers and mo illustrated. The operation of simple equiv	odern controller like predictive controller or fuz valent circuits will be discussed.	zzy controller or neui	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 specifi	c 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 Med	dical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Cor	ntrol and Power Systems Engineering: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsor	У	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elect	tive Compulsory	
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Electiv	re Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Compulso	ory	

Course L0664: Feedback Cor	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 M1384: Case	Studies for Regenerative Medicine and Tissue Engineering
Courses	
Title	Typ Hrs/wk CP
Case Studies for Regenerative Med	ficine and Tissue Engineering (L1963) Seminar 3 6
Module Responsible	Prof. Ralf Pörtner
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	After successfully participating in the module case studies on regenerative medicine and tissue engineering, the students
	can recognize, how a team works together to work on a complex task
	<ul> <li>can assign, which planning tools are required for new cell-based therapy concepts and medical products from the "proof-of-of-of-of-of-of-of-of-of-of-of-of-</li></ul>
	concept" to successful market approval
	can illustrate, which obstacles and difficulties arise during the market approval of the concepts and products mentioned
Skills	After successful completion of the module students are
	able to use relevant 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 analyse and evaluate current research topics and applications for Tissue Engineering and Regenerative Medicine.
Danis and Comments and	
Personal Competence	Students are able to work together as a team with 6-8 students to solve given tasks and discuss their results in the plenary and to
30Clai Competence	defend them.
	Students are able to reflect their work orally and discuss it with other students and teachers.
Autonomy	· ·
riaconomy	independently
	including a presentation of the results.
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 Artificial Organs and Regenerative Medicine: Compulsory
Following Curricula	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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	The students should work in working groups to develop concepts for the path from "proof of concept" to successful market approval for new cell-based therapy concepts and medical products. It is assumed that an initial test phase was successful for the respective concepts. A routine clinical application must now be established in each case. Strategies are to be developed for this.
Literature	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540

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	2) 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 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 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		
Autonomy	given problems.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination		
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 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	d Applications (L0371)		Lecture		3	5
Bioelectromagnetics: Principles and	d Applications (L0373)		Recitation Se	ection (small)	2	1
Module Responsible	Prof. Christian Schuste	er				
Admission Requirements	None					
Recommended Previous	Basic principles of phy	/sics				
Knowledge						
Educational Objectives	After taking part succe	essfully, students have re	eached the following learning r	esults		
Professional Competence	3 1 3 1		<u> </u>			
Knowledge	Students can explain t	the basic principles, rela	tionships, and methods of bioe	lectromagnetics,	i.e. the quantific	ation and applicati
	of electromagnetic fie	elds in biological tissue.	They can define and exemplif	y the most impo	ortant physical ph	nenomena and ord
	them corresponding t	to wavelength and frequ	uency of the fields. They can	give an overvie	w over measure	ment and numeri
	techniques for charac	terization of electromag	netic fields in practical applic	ations . They ca	n give examples	for therapeutic a
	diagnostic utilization of	of electromagnetic fields	in medical technology.			
Skills			to characterize the behavior of			
	_		he elementary solutions of Ma		•	
	-		for biological tissue, they car			
			them in a quantitative way. T			
	l ·	able to evaluate the effe	cts of electromagnetic fields fo	r therapeutic an	d diagnostic appli	ications and make
	appropriate choice.					
Personal Competence						
•	Students are able to	work together on subjec	t related tasks in small group	s. They are able	to present their	results effectively
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	English (e.g. during sn		3	.,		,
Autonomy	Students are capable	to gather information	from subject related, professi	ional publication	s and relate tha	t information to t
	context of the lecture	. They are able to make	a connection between their k	nowledge obtair	ned in this lecture	with the content
	other lectures (e.g. tl	heory of electromagneti	c fields, fundamentals of elec	trical engineerin	g / physics). The	y can communica
	problems and effects	in the field of bioelectror	nagnetics in English.			
Workload in Hours	Independent Study Tir	me 110, Study Time in Le	ecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
Formation ***	Yes None	Presentation				
Examination Examination duration and	Oral exam 45 min					
scale	45 111111					
Assignment for the	Floatrical Engineering	Chocialization Micro	o Engineering Ontice and Fla	ctromagnetic C-	mpatibility Flat	vo Compulsory
Following Curricula			ve Engineering, Optics, and Ele Fechnology: Elective Compulso		impatibility: Electi	ve Compuisory
i onowing curricula			pecialisation II. Electrical Engin		Compulsory	
	_		ement and Business Administra	-		
	_		ts and Endoprostheses: Electiv		paisoi y	
			LO GITA ETTAOPTOSKITOSCS, ETCKLIV	c compaisory		
	_		al Organs and Regenerative Me	dicine: Flective	Compulsory	
	Biomedical Engineerin	g: Specialisation Artificia	al Organs and Regenerative Me I Technology and Control Theo			

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

Course L0373: Bioelectromag	urse L0373: Bioelectromagnetics: Principles and Applications				
Тур	citation 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**

Modulo M0622, Intelli	igent Systems i	Modisino				
Module M0623: Intelli	igent Systems II	1 Medicine				
Courses						
Title				Тур	Hrs/wk	СР
Intelligent Systems in Medicine (L0	331)			Lecture	2	3
Intelligent Systems in Medicine (L0	334)			Project Seminar	2	2
Intelligent Systems in Medicine (L0	333)			Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlae	fer				
Admission Requirements	None					
<b>Recommended Previous</b>	• principles of me	th (algebra, analysis/cal	outus)			
Knowledge	principles of ma     principles of sto		cuius)			
		gramming, Java/C++ ar	ıd R/Matlah			
	advanced progr		ia iyiladab			
	auvaneca progr					
<b>Educational Objectives</b>	After taking part succe	ssfully, students have re	eached the followi	ng learning results		
<b>Professional Competence</b>						
Knowledge	The students are able	to analyze and solve cl	inical treatment p	lanning and decision suppor	rt problems using	methods for search,
	optimization, and plan	ning. They are able to e	xplain methods fo	r classification and their resp	pective advantage	s and disadvantages
	in clinical contexts. The	e students can compare	different method	s for representing medical k	nowledge. They ca	an evaluate methods
	in the context of clinic	al data and explain cha	llenges due to th	e clinical nature of the data	and its acquisition	and due to privacy
	and safety requiremen	ts.				
Skills	The students can give	reasons for selecting a	nd adapting meth	ods for classification, regres	ssion and predicti	on They can assess
Sim S	_	actual patient data and			sololi, alla prealet.	oey ca assess
	the methods sused on	accaar pacient aaca ana	evaluate the imp.			
Personal Competence						
Social Competence	The students are able	to grasp practical task	s in groups, deve	lop solution strategies inde	pendently, define	work processes and
	work on them collaboratively.					
	The students can critically reflect on the results of other groups, make constructive suggestions for improvement and also					
	incorporate them into	heir own work.				
Autonomy				their work results. They can	critically evaluate	the results achieved
	and present them in an appropriate argumentative manner to the other groups.					
Workload in Hours		ne 110, Study Time in Le	ecture 70			
Credit points	6 Compulsory Bonus	Form	Description			
Course achievement	Compulsory Bonus Yes 10 %	Form Written elaboration	Description			
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale	50 minutes					
Assignment for the	Computer Science: Sa	ecialisation II: Intelligenc	e Engineering: Els	active Compulsory		
Following Curricula		_				
i onowing curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Interdisciplinary Mathematics: Specialisation Computational Methods in Biomedical Imaging: Compulsory					
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: 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 Medical Technology and Control Theory: Elective Compulsory					
	_	,		ss Administration: Elective C		
	_			ical Technology: Elective Co		
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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	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	

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	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 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	2
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
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	6			
Assignment for the	Biointedical Engineering: Specialisation implants and t			
Assignment for the Following Curricula		ology and Control Theory: Elective Com	pulsory	
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Course L1663: Nature's Hier	archical Materials
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
<b>Examination duration and</b>	
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		
Language		
	SoSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed.	
	Topics:	
	- Fundamental properties and phenomena of electrical circuits	
	- Steady-state sinusoidal analysis of electrical circuits	
	- Fundamental properties and phenomena of electromagnetic fields and waves	
	- Steady-state sinusoidal description of electromagnetic fields and waves	
	- Useful microwave network parameters - Transmission lines and basic results from transmission line theory	
	- Plane wave propagation, superposition, reflection and refraction	
	- General theory of waveguides	
	- Most important types of waveguides and their properties	
	- Radiation and basic antenna parameters	
	- 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)	

ourse 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	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical
	knowledge is provided.
	1. Tribology
	2. Optical Methods
	3. Motion Analysis
	4. Pressure Distribution
	5. Strain Gauges
	6. Pre-clinical testing
	7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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 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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Time	Lecture
Тур	
Hrs/wk	
CP	4
Workload in Hours	
Examination Form	Klausur
xamination duration and	
scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	Differential acceptance for a second
	Differential equations for momentum-, heat and mass transfer     Transplanter for simplifications of the Navier Stales Equations
	<ul> <li>Examples for simplifications of the Navier-Stokes Equations</li> <li>Unsteady momentum transfer</li> </ul>
	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, Heidelbe
	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 Strömung
	Springer Verlag, Berlin, Heidelberg, New York, 2006.
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / G\
	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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	<ul> <li>Instruction and modelling of physical processes</li> <li>Modelling and limits of model</li> <li>Time constant, stiffness, stability, step size</li> <li>Terms of object orientated programming</li> <li>Differential equations of simple systems</li> <li>Introduction into Modelica</li> <li>Introduction into simulation tool</li> <li>Example: Hydraulic systems and heat transfer</li> <li>Example: System with different subsystems</li> </ul>
Literature	<ul> <li>[1] Modelica Association: "Modelica Language Specification - Version 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	63)	Seminar	2	3
Introduction to Waveguides, Antenn	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anteni	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	2
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
Module Responsible	Prof. Michael Morlock			
<b>Admission Requirements</b>	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	ology and Control Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Management a			
	Biomedical Engineering. Specialisation Management	and business / driminstrution. Elective et	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	

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	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
	The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical knowledge is provided.  1. Tribology 2. Optical Methods 3. Motion Analysis 4. Pressure Distribution 5. Strain Gauges 6. Pre-clinical testing 7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen  White A.A., Panjabi M.M.: Clinical biomechanics of the spine  Nigg, B.: Biomechanics of the musculo-skeletal system  Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/

Course L1580: Experimental	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Dr. Shan Shi
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
<b>Examination Form</b>	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	Dr. Gerd Huber, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Trem	Lecture
Тур	
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 the Section Region of the Section S
	Flow around particles - Solids Process Engineering
	Coupling of momentum and heat transfer - Thermal Process Engineering  Plantage Pinanage Fair and transfer - Thermal Process Engineering  Plantage Pinanage Fair and transfer - Thermal Process Engineering  Plantage Pinanage Fair and transfer - Thermal Process Engineering  Plantage Pinanage Fair and transfer - Thermal Process Engineering  Plantage Pinanage Pinanage Fair and transfer - Thermal Process Engineering  Plantage Pinanage Pinanag
	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. Drawe H. Cavadla and de Finahana and Mahanhananhii awaran Vada Cavadii ada Asaw. Faraffuri (M. 1071
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.
	<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
	<ol> <li>Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne GWV Fachverlage GmbH, Wiesbaden, 2009.</li> </ol>
	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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica 1.17.0.
	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 3.5", Linköping, Sweden, 2021.</li> <li>[2] OpenModelica: OpenModelica 1.17.0, https://www.openmodelica.org (siehe Download), 2021.</li> <li>[3] M. Tiller: "Modelica by Example", https://book.xogeny.com, 2014.</li> <li>[4] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</li> <li>[5] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</li> <li>[6] 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, Dr. Johannes Brunnemann
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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				
<b>Educational Objectives</b>	After taking part successfully, students have re	eached the following learning results		
<b>Professional Competence</b>				
Skills	can be discussed in terms of decision probler world scenarios, students can summarize how formalism in static and dynamic settings. In a settings, with and with complete access to the solving (partially observable) Markov decision. Students can identify techniques for simultant desired states. Students can explain coordinate of equilibria, social choice functions, voting process of the social choice functions, voting process of the social choice functions and apply networks/dynamic Bayesian networks and an different sampling techniques for simplified and best action or policies for concrete settings. In	- '	For dealing with whedge represent procedures in sistudents can destinate the winder of	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				
•	Students are able to discuss their solutions to	problems with others. They communicate in Eng	glish	
4.4		No. of contract to the contract of		
Autonomy	Students are able of checking their understand	ang of complex concepts by solving varants of	concrete problem	15
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Consulta and the	6			
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	e Engineering: Elective Compulsory		
Course achievement Examination Examination duration and scale	Written exam 90 minutes  Computer Science: Specialisation II: Intelligence	te Engineering: Elective Compulsory Decialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam 90 minutes  Computer Science: Specialisation II: Intelligence	pecialisation II. Information Technology: Elective	e Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation II: Intelligenc Mechatronics: Technical Complementary Course Mechatronics: Specialisation Intelligent System	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation II: Intelligenc International Management and Engineering: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C		
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligenc International Management and Engineering: Specialisation II: Intelligenc International Management and Engineering: Specialisation Intelligent System Mechatronics: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implant	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C ts and Endoprostheses: Elective Compulsory	Compulsory	
Course achievement Examination Examination duration and scale Assignment for the	Written exam  90 minutes  Computer Science: Specialisation II: Intelligence International Management and Engineering: Specialisation II: Intelligence International Management and Engineering: Specialisation Intelligent System Mechatronics: Specialisation Intelligent System Biomedical Engineering: Specialisation Artificial Biomedical Engineering: Specialisation Implantation Biomedical Engineering: Specialisation Medical Engineering: Specialisation Medical	pecialisation II. Information Technology: Elective se: Elective Compulsory ns and Robotics: Elective Compulsory al Organs and Regenerative Medicine: Elective C	Compulsory	

Typ	Lecture
	2
	4
_	Independent Study Time 92, Study Time in Lecture 28
	EN EN
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 Autonomous Agents and Cognitive Robotics		
Тур	Recitation Section (small)	
Hrs/wk		
СР	2	
Workload in Hours	dependent Study Time 32, Study Time in Lecture 28	
Lecturer	niner Marrone	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

Module M0751: Vibra	tion Theory				
Courses					
Title Vibration Theory (L0701)	Typ Hrs/wk CP Integrated Lecture 4 6				
Module Responsible	Prof. Norbert Hoffmann				
Admission Requirements	None				
Recommended Previous Knowledge	Calculus				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results				
Professional Competence Knowledge					
Skills	<ul> <li>Students are able to denote methods of Vibration Theory and develop them further.</li> <li>Students are able to apply and expand methods of modeling and simulation for free, forced, self-excited and paran driven vibrations.</li> <li>Students are able to solve linear and nonlinear vibration problems.</li> </ul>				
Personal Competence Social Competence Autonomy	<ul> <li>Students can analyze vibration problems, work on them, and reach working results also in teams or groups.</li> <li>Students are able to document the results of vibration studies also in groups.</li> </ul>				
	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 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 Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory				

Course L0701: 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 Vibrations
	Free vibration  Self-excited vibration  Parameter driven vibration  Forced vibration  Multi degree of freedom vibration  Continuum vibration  Irregular vibration
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen.
	English - K. Magnus: Vibrations.

Module M0814: Techr	nology Management					
Courses						
Title		Тур	Hrs/wk	СР		
Technology Management (L0849)	Lecture	3	3			
Technology Management Seminar	ar (L0850) Project-/problem-based Learning 2 3					
Module Responsible	Prof. Cornelius Herstatt					
Admission Requirements						
	Bachelor knowledge in business management					
Knowledge	After taking part suggestibly students have reached the falls	uving learning regults				
Professional Competence	After taking part successfully, students have reached the follo	wing learning results				
	Students will gain deep insights into:					
	International R&D-Management  Tacked to a Timin Chataging					
	Technology Timing Strategies     Technology Strategies and Lifecusia Management	.+ (I/II)				
	<ul><li>Technology Strategies and Lifecycle Managemer</li><li>Technology Intelligence and Planning</li></ul>	it (I/II)				
	Technology Portfolio Management					
	Technology Portfolio Methodology					
	<ul> <li>Technology Acquisition and Exploitation</li> </ul>					
	IP Management					
	Organizing Technology Development					
	Technology Organization & Management					
	<ul> <li>Technology Funding &amp; Controlling</li> </ul>					
Skills	The course aims to:					
	Develop an understanding of the importance of Technol	logy Management - on a national a	s well as interr	national level		
	• Equip students with an understanding of importa	nt elements of Technology Mar	nagement (str	ategic, operational,		
	organizational and process-related aspects)					
	Foster a strategic orientation to problem-solving within	n the innovation process as well as	s Technology N	Management and its		
	importance for corporate strategy  Clarify activities of Tochnology Management (e.g. tochnology sourcing, maintenance and exploitation)					
	<ul> <li>Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation)</li> <li>Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues</li> </ul>					
	<ul> <li>Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&amp;D-management. Further topics to be discussed include:</li> </ul>					
	Basic concepts, models and tools, relevant to the management of technology, R&D and innovation     Innovation as a process (steps, activities and results)					
	<ul> <li>Innovation as a process (steps, activities and results)</li> </ul>					
Personal Competence						
Social Competence	e • Interact within a team					
	Raise awareness for globabl issues					
	-					
Autonomy	Gain access to knowledge sources					
	Discuss recent research debates in the context of Tech	nology and Innovation Managemen	t			
	Develop presentation skills					
	Discussion of international cases in R&D-Management					
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70					
Credit points						
Course achievement						
Examination						
Examination duration and scale	30 minutes					
Assignment for the	Global Innovation Management: Core Qualification: Compulso	ry				
Following Curricula		•	npulsory			
-	Mechanical Engineering and Management: Specialisation Man	agement: Elective Compulsory				
	Biomedical Engineering: Specialisation Artificial Organs and R	egenerative Medicine: Elective Con	npulsory			
	Biomedical Engineering: Specialisation Implants and Endopros					
	Biomedical Engineering: Specialisation Medical Technology ar		sory			
	Biomedical Engineering: Specialisation Management and Busi	ness Administration: Compulsory				

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

Courses		
Title	Typ Hrs/wk	
Microsystems Technology (L0724)		4
Microsystems Technology (L0725)		2
Module Responsible		
Admission Requirements		
Recommended Previous	, , , , , , , , , , , , , , , , , , ,	
Knowledge		
Educational Objectives		
Professional Competence		
Knowieage	Students are able	
	to present and to explain current fabrication techniques for microstructures and especially meth	ods for the fabricatio
	microsensors and microactuators, as well as the integration thereof in more complex systems	
	to explain in details operation principles of microsensors and microactuators and	
	to explain in actains operation principles of microscensors and microactactors and	
	to discuss the potential and limitation of microsystems in application.	
Skills	Students are capable	
	to analyze the feasibility of microsystems,	
	to develop process flows for the fabrication of microstructures and	
	to apply them.	
Personal Competence		
Social Competence		
	Students are able to plan and carry out experiments in groups, as well as present and represent the	
	These social skills are practiced both during the preparation phase, in which the groups work out and	
	during the follow-up phase, in which the groups prepare, document and present their practical experience	es.
Autonomy		
	ever new boundary conditions. This requirement is communicated at the beginning of the semester and c	
	the exam. Students are encouraged to work independently by not being given a solution, but by learning	
	step by step by asking specific questions. Students learn to ask questions independently when they a	re faced with a probl
	They learn to independently break down problems into manageable sub-problems.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement	Compulsory Bonus Form Description  Yes None Subject theoretical and Studier enden führen in Kleingruppen ein Laborprakt	kum durch lede Gru
	practical work präsentiert und diskutiert die Theorie sowie die Ergeb	
	vor dem gesamten Kurs.	inise inier Eubortatigi
Examination		
Examination duration and		
scale		
Assignment for the		,
Assignment for the Following Curricula		
rollowing Curricula	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory  Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory. Elective Compulsory  Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	I Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine, Elective Compilisory	

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul> <li>Introduction (historical view, scientific and economic relevance, scaling laws)</li> <li>Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)</li> <li>Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)</li> <li>Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching)</li> <li>Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SUB, rapid prototyping)</li> <li>Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)</li> <li>Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate 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 gas sensor, Organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of b</li></ul>
	<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> <li>Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship)</li> <li>System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)</li> </ul>
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002  N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009  T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

Module M0846: Contr	rol Systems Theory and Desig	gn			
Courses					
Title		Тур	н	lrs/wk	СР
Control Systems Theory and Desig	n (L0656)	Lecture	2		4
Control Systems Theory and Desig	n (L0657)	Recitation Section	on (small) 2		2
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous	Introduction to Control Systems				
Knowledge					
	After taking part successfully, students ha	ave reached the following learning resu	Its		
Professional Competence  Knowledge					
Skills	response to initial states or externa  They can explain the system propestimation, respectively  They can explain the significance of they can explain observer-based soor they can extend all of the above to 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 the they can explain how a state space of they can assess controllability and they can design LQG controllers for they can carry out a controller defor a given sampling rate of they can identify transfer function	tate feedback and how it can be used to multi-input multi-output systems and its relationship with the Laplace Tralels and transfer function models of discridentification of ARX models of dynamiation e model can be constructed from a discriction models into state space models all observability and construct minimal reservables.	o achieve tracking and their relationsly of achieve tracking and setting and setting and setting and setting and vice versal and vice versal and vice versal and setting and setting domain, and amic systems from	hip to state f and disturban v the identific response	feedback and state fince rejection cation problem can finich is appropriate
	Students can work in small groups on spe Students can obtain information from prowhen solving given problems. They can assess their knowledge in week	rovided sources (lecture notes, softwa	re documentation,		guides) and use it
Workload in Hours Credit points		: III LECCUIE 30			
<u> </u>					
Course achievement	None Written exam				
Examination duration and scale					
	Electrical Engineering: Core Qualification:	Compulsory			
Following Curricula					
<b>3</b> y	Aircraft Systems Engineering: Core Qualif				
	Computer Science in Engineering: Special	lisation II. Engineering Science: Elective	Compulsory		
	International Management and Engineerin			ılsory	
	International Management and Engineerin				
	Mechanical Engineering and Management		Compulsory		
	Mechatronics: Core Qualification: Compul Biomedical Engineering: Specialisation Ar	•	ine: Flective Compu	ılsorv	
	Biomedical Engineering: Specialisation Im			y	
	Biomedical Engineering: Specialisation Me				
	Biomedical Engineering: Specialisation Ma	**		ory	
	Product Development, Materials and Prod	luction: Core Qualification: Elective Com	npulsory		
	Theoretical Mechanical Engineering: Core	Qualification: Compulsory			

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

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	ction Planning & Control and	d Digital Enterprise		
ourses				
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	0930)	Recitation Section (small)	1	1
xercise: The Digital Enterprise (L0	933)	Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality N	Management		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-  -			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineerin	ng: Specialisation II. Product Development and Produ	uction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spe	cialisation Production and Logistics: Elective Compu	Isory	
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory		pulsory		
	Biomedical Engineering: Specialisation Ma	anagement and Business Administration: Compulsor	- 'y	
	Product Development, Materials and Prod	luction: Specialisation Product Development: Electiv	e Compulsory	
	•	luction: Specialisation Production: Compulsory	. ,	
	·	luction: Specialisation Materials: Elective Compulsor	у	
	• •	cialisation Product Development and Production: Ele	*	

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. Robert Rost	
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	cture	
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 Pl	urse 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. Robert Rost	
Language	DE	
Cycle	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Courses				
<b>Title</b> Continuum Mechanics (L1533)		<b>Typ</b> Lecture	Hrs/wk 2	<b>CP</b> 3
Continuum Mechanics (£1333)  Continuum Mechanics Exercise (£1	.534)	Recitation Section (small)	2	3
Module Responsible				
Admission Requirements	,			
		eering Mechanics I and Engineeri	ng Mechanics II	at TUHH (forces a
Knowledge	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics I and Engineering Mechanics II at TUHH (forces a moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy); basics of mathematics as taugl			
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
<b>Educational Objectives</b>	After taking part successfully, students have reached the fol	llowing learning results		
<b>Professional Competence</b>				
Knowledge	In this module, students learn the fundamental concepts	of nonlinear continuum mechan	ics. This theory	enables students
	describe arbitrary deformations of continuous bodies (solid,			
	of the basic module Engineering Mechanics II (elastostatics		opic, linear-elasti	ic material behavio
	small deformations, simple geometries) of which are success	sively eliminated.		
	First, the students learn the necessary fundamentals of tens	or calculus. Based on this, the de	scription of the d	eformations / strai
	of arbitrarily deformable bodies is dealt with. The students l	learn the mathematical formalism	for characterizing	ng the stress state
	a body and for formulating the balance equations for mass			
	students know which constitutive assumptions have to be m	nade for modeling the material bel	navior of a mecha	anical body.
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		problems of solid mechanics, to	present them to	specialists in writte
,	form and to develop ideas further.			•
Autonomy	The students are able to assess their own strengths and we	aknesses. They can independentl	y and on their ov	vn identify and sol
	problems in the area of continuum mechanics and acquire the	he knowledge required to this end		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	, , , , , , , , , , , , , , , , , , , ,			
Course achievement				
Examination	Written exam			
Examination duration and	60 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Compuls	sory		
Following Curricula	Mechanical Engineering and Management: Specialisation Ma	aterials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs and	-	Compulsory	
	Biomedical Engineering: Specialisation Implants and Endopr			
	Biomedical Engineering: Specialisation Medical Technology a		-	
	Biomedical Engineering: Specialisation Management and Bu- Product Development, Materials and Production: Core Qualif		приіѕогу	
	Theoretical Mechanical Engineering: Core Qualification: Elec			
		and compaisory		

Course L1533: Continuum Me	achanics
Тур	Lecture
Hrs/wk	
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Cycle	WiSe Continuum mechanics is a general theory to describe the effect of mechanical forces on continuous mechanical (both solid and fluid) bodies. An important part of continuum mechanics is the mathematical description of strains and stresses as well as the stress-strain response of continuous mechanical bodies. The lecture continuum mechanics builds on the foundations tought in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) the focus was by and large limited to small deformations of simple bodies under simple loading, the lecture continuum mechanics introduces a general mathematical framework to deal with arbitrarily shaped bodies under arbitrary loading undergoing very general kinds of deformations. This lecture focuses primarily on theoretical aspects of continuum mechanics but its content is key to numerous applications in modern engineering, for example, in production, automotive, and biomedical engineering. The lecture covers:  • 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  • Spectral decomposition  • Objectivity  • Strain measures  • Transport theorems  • Strain and deformation rates  • Transport theorems  • Balance equations (global and local form)  • Balance of mass  • The stress state  • Surface traction vectors  • Cauchy's fundamental theorem  • Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)
	<ul> <li>Balance of angular momentum</li> <li>Balance of energy</li> <li>Balance of entropy</li> <li>Clausius-Duhem inequality</li> </ul>
	<ul> <li>Constitutive laws</li> <li>Constitutive assumptions</li> <li>Fluids</li> <li>Elastic solids</li> </ul>
	<ul> <li>Hyperelasticity</li> <li>Material symmetry</li> <li>Elasto-plastic solids</li> <li>Analysis</li> <li>Initial-boundary value problems and their numerical solution</li> </ul>
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Course L1534: Continuum Mo	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	The exercise on Continuum Mechanics explains the theoretical content of the lecture on Continuum Mechanics by way of a series of specific example problems.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker
	I-S. Liu: Continuum Mechanics, Springer

Courses				
<b>Fitle</b> Material Modeling (L1535)	<b>Typ</b> Lecture		Hrs/wk 2	<b>CP</b> 3
Material Modeling (L1535)		ection (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements				
Recommended Previous	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics	I and Engineer	ing Mechanics II	at TUHH (forces
Knowledge	moments, stress, linear strain, free-body principle, linear-elastic constitutive l	aws, strain ener	gy); basics of ma	thematics as tau
	e.g., in the modules Mathematics I and Mathematics II at TUHH			
Educational Objectives		esults		
Professional Competence		v vissoolostisit	, and claste place	ticity in the reals
Knowieage	The students understand the theoretical foundations of anisotropic elasticity three-dimensional (linear) continuum mechanics. In the area of anisotropic el			
	and its application in orthotropic, transversely isotropic and isotropic mate		•	-
	compliance and how both can be characterized by appropriate parameters. M			
	in the time and frequency domain using the concepts of relaxation modulus,			-
	the area of elasto-plasticity, the students know the concept of yield stress	or (in higher dir	nensions) yield s	urface and of pla
	potential. Additionally, the know the concepts of ideal plasticity, hardening	ng and weaken	ing. Moreover, th	hey know von-M
	plasticity as a specific model of elasto-plasticity.			
Skills	The students can independently identify and solve problems in the area of ma	aterials modelin	g and acquire the	knowledge to do
	This holds in particular for the area fo anisotropically elastic, viscoelastic and			
	students can independently develop models for complex material behavi		-	•
	understand relevant literature and identify the relevant results reported the			
	developed or found in the literature in computational software (e.g., based of calculations.	on the finite ele	ment method) an	id use it for pract
Personal Competence				
Social Competence				
	to discuss challening problems of materials modeling with experts using the proper terminoloy, to identify and ask criti			
	questions in such discussions and to identify and discuss potential caveats in		-	
Autonomy	The students have the ability to independently develop abstract models that	allow them to cl	assify observed p	henomena withir
	more general abstract framework and to predict their further evolution. Mo			3
	also limitations of mathematical models and can thus independently decide v	when and to whi	ch extent they m	ake sense as a b
	for decisions.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement				
Examination				
Examination duration and scale				
	Materials Science: Specialisation Modeling: Elective Compulsory			
Following Curricula		Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Me		Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective		, , ,	
	Biomedical Engineering: Specialisation Medical Technology and Control Theor		pulsory	
	Biomedical Engineering: Specialisation Management and Business Administra	tion: Elective Co	mpulsory	
	Product Development, Materials and Production: Core Qualification: Elective C	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective	Compulsory		
	Theoretical Mechanical Engineering: Specialisation Simulation Technology: Ele	ective Compulso	rv	

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

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

Module M1199: 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 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 no
	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 technic
	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	octional 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. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Robert Meißner, Prof. Kaline Pagnan
	Furlan
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.

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 ha	ave reached the following learning results		
Professional Competence				
Knowledge	The students can			
	and the state of t			
	describe basic biomolecules;      avalain bay constitution information is	sadad in the DNA.		
	explain how genetic information is			
	<ul> <li>explain the connection between DI</li> </ul>	NA and proteins;		
Skills	The students can			
		rular parameters for the course of a disease;		
	describe selected molecular-diagnorm     avalage the relevance of these pro-			
	<ul> <li>explain the relevance of these pro-</li> </ul>	cedures for some diseases		
Personal Competence				
Social Competence	The students can participate in discussion	ns in research and medicine on a technical lev	vel.	
	Students will have an improved underst	randing of surrent modical problems (o.g. C	orono nandomisland will	he able to eval
	these issues to others.	randing of current medical problems (e.g. Co	orona pandemicjand wiii	be able to expla
	these issues to others.			
Autonomy	The students can develop an understand	ing of topics from the course, using technical	literature by themselves	
Autonomy	The students can develop an understand	ing of topics from the course, using technical	interactive, by themselves	
	Students will be better equipped to recog	nize fake news in the media regarding medic	al research topics.	
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	60 minutes			
scale				
Assignment for the	General Engineering Science (German pro	ogram, 7 semester): Specialisation Biomedica	I Engineering: Compulsor	у
Following Curricula	General Engineering Science (German	program, 7 semester): Specialisation Med	chanical Engineering, Fo	cus Biomechani
	Compulsory			
	Electrical Engineering: Specialisation Med	lical Technology: Elective Compulsory		
	Engineering Science: Specialisation Biom	edical Engineering: Compulsory		
	General Engineering Science (English pro	gram, 7 semester): Specialisation Biomedical	Engineering: Compulsory	,
	Mechanical Engineering: Specialisation Bi	omechanics: Compulsory		
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation Ar	tificial Organs and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Electiv	re Compulsory	
	Biomedical Engineering: Specialisation In	plants and Endoprostheses: Elective Compul	sory	

Course L0386: Introduction to Biochemistry and Molecular Biology		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Hans-Jürgen Kreienkamp	
Language	DE	
Cycle	WiSe	
Content		
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 cuse.		
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.

Module M0808: Finite	Elements Methods			
Courses				
Title		Tun	Hrs/wk	СР
Finite Element Methods (L0291)		<b>Typ</b> Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous		II (II) drostatics Kinematics Dun	amica)	
	Mechanics I (Statics, Mechanics of Materials) and Mechanics	s II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the fo	ollowing learning results		
Professional Competence				
Knowledge	The students possess an in-depth knowledge regarding t	the derivation of the finite eleme	ent method and	are able to give
3	overview of the theoretical and methodical basis of the met			3
Skills	The students are capable to handle engineering problems system matrices, and solving the resulting system of equat		ments, assemblin	g the correspondi
	Students can work in small groups on specific problems to a The students are able to independently solve challengin Problems can be identified and the results are critically scru	g computational problems and c	levelop own finit	e element routin
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description	on	<u> </u>	
	No 20 % Midterm			
Examination	Written exam			
<b>Examination duration and</b>	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Compulsory			
_	Energy Systems: Core Qualification: Elective Compulsory			
, and the second	Aircraft Systems Engineering: Core Qualification: Elective C	ompulsory		
	International Management and Engineering: Specialisation	, ,	nrv	
	International Management and Engineering: Specialisation			amnulsory
		Froduct Development and Produ	iction. Liective Cl	ompuisory
	Mechatronics: Core Qualification: Compulsory	rosthosos, Compulsos,		
	Biomedical Engineering: Specialisation Implants and Endop			
	Biomedical Engineering: Specialisation Management and Bu		. ,	
	Biomedical Engineering: Specialisation Medical Technology	· ·	-	
	Biomedical Engineering: Specialisation Artificial Organs and	•	Compulsory	
	Product Development, Materials and Production: Core Quali			
	Technomathematics: Specialisation III. Engineering Science			
	Theoretical Mechanical Engineering: Core Qualification: Cor	npulsory		

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	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		

evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example.  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 constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps  - 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 duration and scale  Assignment for the Following Curricula  Biomedical Engineering: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Anagement and Business Administration: Elective Materials: Elective Medicine: Elective Engineering: Specialisation Management and Business Administration: Elective Engineering: Specialisation Engineering: Specialisation Engineering: Sp		
Personal Competence  Social Comp	_	
Module Responsible Admission Requirements Recommended Previous Knowledge Educational Objectives Knowledge Educational Objectives Knowledge Educational Competence Knowledge  Educational Objectives Knowledge Students can use the knowledge of plastics and define the necessary testing and ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical prog- evaluate the different materials selecting appropriate solutions for mechanical recycling problems and sizing examp  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 construction assesses their own strengths and weaknesses assess their own strengths and their professional activity.  Workload in Hours  Workload in Hours  independent Study Time 124, Study Time in Lecture 56  Course achievement Examination Written exam  Examination duration and scale  Assignment for the Following Curricula Biomedical Engineering: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Annangement and Business Administration: Ele Biomedical Engineering: Specialisation Manangement and Business Administration: Ele	Hrs/wk	СР
Module Responsible Dr. Hans Wittich  Admission Requirements None  Recommended Previous Knowledge Basics: chemistry / physics / material science  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 ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical propersulate the different materials selecting appropriate solutions for mechanical recycling problems and sizing exampers and sizing exampers are funded work results in heterogenius groups and document them provide appropriate feedback and handle feedback on their own performance constructions are able to - assess their own state of learning in specific terms and to define further work steps - assess possible consequences of their professional activity.  Workload in Hours Independent Study Time 124, Study Time in Lecture 56  Course achievement Study Time 124, Study Time in Lecture 56  Course achievement Written exam Examination duration and scale  Assignment for the Following Curricula Biomedical Engineering: Specialisation implants and Endoprostnesses: Compulsory Biomedical Engineering: Specialisation implants and Endoprostnesses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Medicine: Elective	2	3
Admission Requirements Recommended Previous Knowledge Educational Objectives Professional Competence Knowledge  Evantage of plastics and define the necessary testing and ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical propersonal Competence Social Competence Social Competence Social Competence Social Competence Social They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical propersonal Competence Social 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 constructions are able to - assess their own state of learning in specific terms and to define further work steps - assess possible consequences of their professional activity.  Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Course achievement Examination Virtien exam Examination duration and scale Assignment for the Following Curricula Biomedical Engineering: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation and Regenerative Medicine: Elective Medicine: Electi	2	3
Recommended Previous Knowledge  Educational Objectives  Professional Competence Knowledge  Students can use the knowledge of plastics and define the necessary testing and ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skiils  Students are capable of  - using standardized calculation methods in a given context to mechanical properulate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example exaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example example for the provide appropriate feedback and handle feedback on their own performance constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  -		
Educational Objectives Professional Competence Knowledge Students can use the knowledge of plastics and define the necessary testing and ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring protection).  Skills Students are capable of - using standardized calculation methods in a given context to mechanical propevaluate the different materials selecting appropriate solutions for mechanical recycling problems and sizing examples and 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 constructions 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 - assess possible consequences of their professional activity.  Workload in Hours Independent Study Time 124, Study Time in Lecture 56 Credit points Course achievement None Examination Written exam 180 min scale Assignment for the Materials Science: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Me		
### 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 ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills  Students are capable of  - using standardized calculation methods in a given context to mechanical properly relationships and sizing examples and sizing examples are specified by the standard properly and the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing examples and competence arrive at funded work results in heterogenius groups and document them.  - provide appropriate feedback and handle feedback on their own performance constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps.  - assess their own state of learning in specific terms and to define further work steps.  - assess possible consequences of their professional activity.  Workload in Hours  Credit points  Course achievement  Examination  Mritten exam  Examination duration and scale  Assignment for the Following Curricula  Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory  Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory		
Professional Competence  Knowledge  Students can use the knowledge of plastics and define the necessary testing and ana They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills  Students are capable of  - using standardized calculation methods in a given context to mechanical prop evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing examp  Personal Competence  Students can  - arrive at funded work results in heterogenius groups and document them.  - provide appropriate feedback and handle feedback on their own performance constr  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps  - assess possible consequences of their professional activity.  Workload in Hours  Credit points  Course achievement None  Examination  Examination duration and scale  Assignment for the Following Curricula Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Ele		
They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighborin protection).  Skills  Students are capable of  - using standardized calculation methods in a given context to mechanical propevaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing exampements.  Personal Competence  Social 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 constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps - assess possible consequences of their professional activity.  Workload in Hours  Independent Study Time 124, Study Time in Lecture 56  Credit points  Course achievement  Mritten exam  180 min  Examination duration and scale  Assignment for the Following Curricula  Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory		
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protection).  Skills  Students are capable of  - using standardized calculation methods in a given context to mechanical properties of evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example.  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 constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps  - assess possible consequences of their professional activity.  Workload in Hours  Independent Study Time 124, Study Time in Lecture 56  Credit points  Credit points  Credit points  Gurse achievement  None  Examination duration and scale  Assignment for the Following Curricula  Materials Science: Specialisation Engineering Materials: Elective Compulsory  Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory  Biomedical Engineering: Specialisation Management and Business Administration: Elective Management and Business Administration: E		
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evaluate the different materials.  - selecting appropriate solutions for mechanical recycling problems and sizing example.  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 constructions.  Autonomy  Students are able to  - assess their own strengths and weaknesses.  - assess their own state of learning in specific terms and to define further work steps  - 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  Examination  Written exam  180 min  Examination duration and scale  Assignment for the Following Curricula  Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Specialisation Management and Busine		
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Biomedical Engineering: Specialisation Management and Business Administration: Ele		
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Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electi		
Product Development, Materials and Production: Specialisation Production: Elective Co		
Product Development, Materials and Production: Specialisation Materials: Elective Cor	. ,	
Product Development, Materials and Production: Specialisation Product Development: Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compu	, ,	

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

Module M1333: BIO I:	Implants and Fracture Healing
Courses	
Title	Typ Hrs/wk CP
Implants and Fracture Healing (L03	R76) 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	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
Personal 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 Biomechanics
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
	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	2
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
Litoratura	Cochran V.B.: Orthopädische Biomechanik
Literature	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Courses				
Title		Tree	Han buls	СР
Regenerative Medicine (L0347)		<b>Typ</b> Seminar	Hrs/wk 2	3
Lecture Tissue Engineering - Reger	nerative Medicine (L1664)	Seminar	2	3
Module Responsible	1			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	After successful completion of the module s explain the use of the tissue cells for differen		-	
	the cultivation of animal and human cells.	and and an about engineering. They are	able to give a basic ove	
	The students can outline the actual conce	epts of Tissue Engineering and regener	ative medicine and ca	n explain the bas
	udnerlying principles of the discussed topics.			
Skills	After successful completion of the module str	udents are		
	able to use medical databases for acquart	uirierung and presentation of relevant up-	to-date data independer	ntly
	able to present their work results in th	e form of presentations		
	able to carry out basic cell culture met	hods and the corresponding analysis inde	pendently	
	able to analyse and evaluate current r	esearch topics for Tissue Engineering and	regenerative medicine.	
Personal Competence				
Social Competence	Students are able to work together as a tean defend them.	n with 2-4 students to solve given tasks ar	nd discuss their results i	n the plenary and
	Students are able to reflect their work orally	and discuss it with other students and tea	chers.	
Autonomy				
	After accordation of this readule continues			2.4
	After completion of this module, participal independently including a presentation of the		problem in teams of a	ipprox. 2-4 persoi
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes 20 % Written elaboration	Ausarbeitung zu Ringvorlesung / pro	otocol for lecture series	
Examination	Presentation			
Examination duration and	Oral presentation + discussion (30 min)			
scale				
Assignment for the	Biomedical Engineering: Specialisation Impla	·	•	
Following Curricula		•		
	Biomedical Engineering: Specialisation Mana	-		
	Biomedical Engineering: Specialisation Medic	al 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 M0634: Introd	duction into Me	dical Technology	and Systems		
Courses					
Title			Тур	Hrs/wk	СР
Introduction into Medical Technolog			Lecture	2	3
Introduction into Medical Technolog			Project Seminar	2	2
Introduction into Medical Technolog	I		Recitation Section (large)	1	1
Module Responsible		efer			
Admission Requirements					
Recommended Previous					
Knowledge	principles of stochast principles of program				
	principles of program	ming, K/Matiab			
<b>Educational Objectives</b>	After taking part succ	essfully, students have rea	ched the following learning results		
Professional Competence					
Knowledge	The students can ex	plain principles of medica	l technology, including imaging system	s, computer aided	surgery, and medical
	information systems.	They are able to give an o	verview of regulatory affairs and standar	ds in medical technol	logy.
Skills	The students are able	e to evaluate systems and	medical devices in the context of clinical	applications.	
		,			
Personal Competence					
Social Competence		·	nnology as a project, and define tasks the	•	
	The students can criti	ically reflect on the results	of other groups and make constructive s	uggestions for impro	vement.
4	The shorteness of the			The control of the co	
Autonomy		sess their level of knowle t them in an appropriate m	edge and document their work results.	iney can critically	evaluate the results
	acilieved and present	t trieffi iii aii appropriate iii	anner.		
Workload in Hours	Independent Study Ti	me 110, Study Time in Lec	ture 70		
Credit points	6				
Course achievement	Compulsory Bonus	Form	Description		
	Yes 10 %	Written elaboration			
	Yes 10 %	Presentation			
Examination duration and scale	90 minutes				
Assignment for the	General Engineering	Science (German program	7 semester): Specialisation Biomedical E	naineerina: Compuls	ory
Following Curricula			s and Engineering Science: Elective Com		soi y
		lisation II. Application: Elec		, ,	
		ualification: Elective Comp	• •		
		Core Qualification: Electi;:			
	Engineering Science:	Specialisation Biomedical	Engineering: Compulsory		
	General Engineering	Science (English program,	7 semester): Specialisation Biomedical E	ngineering: Compulso	ory
	Computer Science in	Engineering: Specialisation	II. Mathematics & Engineering Science:	Elective Compulsory	
	_	•	Organs and Regenerative Medicine: Elec		
	_		and Endoprostheses: Elective Compulso		
	3	J 1	Fechnology and Control Theory: Elective	, ,	
	_	•	nent and Business Administration: Electiv	re compulsory	
	recnnomathematics:	Specialisation III. Engineer	ing Science: Elective Compulsory		

Typ Lecture  Hrs/wk 2  CP 3  Workload in Hours  Lecturer Prof. Alexander Schlaefer  Language DE  Cycle SoSe  Content  - imaging systems - computer aided surgery - medical sensor 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  Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Course L0342: Introduction in	nto Medical Technology and Systems
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 Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Тур	Lecture
Workload in Hours  Lecturer Prof. Alexander Schlaefer  Language 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 Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildwerarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Hrs/wk	2
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  Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	СР	3
Language  Cycle SoSe  Content - imaging systems - computer aided surgery - medical sensor systems - medical information 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  Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Cycle 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 Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Lecturer	Prof. Alexander Schlaefer
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- 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  Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011	Content	- imaging 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  Bernhard Priem, "Visual Computing for Medicine", 2014  Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097)  Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015  Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014  H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687)  Wolfgang Drexler, "Optical Coherence Tomography", 2008  Kramme, "Medizintechnik", 2011		- computer aided surgery
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Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011		
Kramme, "Medizintechnik", 2011		
Thorsten M. Buzug, "Computed Tomography", 2008		
Otmar Scherzer, "Handbook of Mathematical Methods in Imaging", 2015		
Weishaupt, "Wie funktioniert MRI?", 2014		·
Paul Suetens, "Fundamentals of Medical Imaging", 2009		· ·
Vorlesungsunterlagen		Vorlesungsunterlagen

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	urse L1876: Introduction into Medical Technology and Systems		
Тур	Recitation Section (large)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Alexander Schlaefer		
Language	DE		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

	tics and Navigation in Medici				
Courses					
<b>Title</b> Robotics and Navigation in Medicir Robotics and Navigation in Medicir	ne (L0338)		Typ Lecture Project Seminar	Hrs/wk 2 2	<b>CP</b> 3 2
Robotics and Navigation in Medicin			Recitation Section (small)	1	1
	Prof. Alexander Schlaefer				
Admission Requirements					
Recommended Previous Knowledge	<ul> <li>principles of math (algebra, analysis)</li> </ul>				
<b>Educational Objectives</b>	After taking part successfully, students ha	ave reached the following	g learning results		
Professional Competence					
Knowledge	The students can explain kinematics and detail. Systems can be evaluated with resystems regarding design and limitations	respect to collision dete			
Skills	The students are able to design and evalu	uate navigation systems	and robotic systems for me	dical applications.	
Personal Competence Social Competence	The students are able to grasp practical	tasks in groups, develo	on solution strategies inder	endently define	work processes an
	work on them collaboratively. The students are able to collaboratively software management tools. The students can critically reflect on the incorporate them into their own work.	organize their work pro	cesses and software soluti	ons using virtual	communication an
Autonomy	The students can assess their level of knowledge and independently control their learning processes on this basis as well a document their work results. They can critically evaluate the results achieved and present them in an appropriate argumentativ manner to the other groups.				
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70			
Credit points					
Course achievement	Compulsory Bonus Form Yes 10 % Written elaboration Yes 10 % Presentation	<b>Description</b>			
Examination	Written exam				
Examination duration and					
scale					
Assignment for the	Computer Science: Specialisation II: Intelli	igence Engineering: Elec	tive Compulsory		
Following Curricula	· ·		, ,		
•	International Management and Engineerin	• •		Compulsory	
	International Management and Engineerin	ng: Specialisation II. Proc	ess Engineering and Biotec	hnology: Elective	Compulsory
	Mechatronics: Specialisation Intelligent Sy	stems and Robotics: Ele	ective Compulsory		
	Biomedical Engineering: Specialisation Ar	tificial Organs and Rege	nerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Im	plants and Endoprosthe	ses: Elective Compulsory		
	Biomedical Engineering: Specialisation Me	edical Technology and C	ontrol Theory: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Ma	anagement and Business	Administration: Elective Co	ompulsory	
	Product Development, Materials and Prod	uction: Specialisation Pr	oduct Development: Electiv	e Compulsory	
	Product Development, Materials and Prod	uction: Specialisation Pr	oduction: Elective Compulso	ory	
	Product Development, Materials and Prod	uction: Specialisation Ma	aterials: Elective Compulsor	у	
	Theoretical Mechanical Engineering: Spec	ialisation Bio- and Medic	al Technology: Elective Con	npulsory	

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 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			
<b>Educational Objectives</b>	After taking part successfully, students have reached the	e following learning results		
<b>Professional Competence</b>				
Knowledge	<ul> <li>Students are able to reflect existing terms and co</li> </ul>	ncents in Nonlinear Dynamics and	d to develop and res	earch new terms and
	concepts.	neepto in nominear by namico and	a to develop and res	caren new terms and
	<ul> <li>Students are able to denote and expand methods</li> </ul>	of modeling and analysis for nonl	inear dynamical syst	ems.
Skills	Students are able to apply existing methods and particles.	procesures of Nonlinear Dynamics		
	Students are able to develop novel methods and particles.	procedures for nonlinear dynamica	al systems.	
Personal Competence				
Social Competence	Students can analyze problems of nonlinear dynamics	mics also in groups.		
	<ul> <li>Students can achieve solution procedures for prob</li> </ul>	lems of nonlinear dynamical syst	ems also in groups.	
Autonomy				
naconomy	Students are able to approach given research task		ndividually.	
	<ul> <li>Students are able to identify and follow up novel r</li> </ul>	esearch tasks 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				
_	Aircraft Systems Engineering: Core Qualification: Elective	• •		
	International Management and Engineering: Specialisation		•	
	Mechanical Engineering and Management: Specialisation	•	ory	
	Mechatronics: Specialisation System Design: Elective Co			
	Mechatronics: Specialisation Intelligent Systems and Rob Biomedical Engineering: Specialisation Artificial Organs a	• •	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and End	-		
	Biomedical Engineering: Specialisation Medical Technolo			
	Biomedical Engineering: Specialisation Management and	•		
	Product Development, Materials and Production: Core Qu			
	Theoretical Mechanical Engineering: Core Qualification: I	Elective Compulsory		

urse 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	
	One dimensional problems  Linear Stability  Local Bifurcations  Synchronisation  Two dimensional problems  Limit Cycles  Global Bifurcations  Chaos  Lorenz Equations  Fractals and Strange Attractors  Predictability and Horizons	
Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.	

Courses				
Γitle		Тур	Hrs/wk	СР
Semiconductor Technology (L0722) Semiconductor Technology (L0723)		Lecture Practical Course	4 2	4 2
Module Responsible	Prof. Hoc Khiem Trieu	Tractical course	2	
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 rea	ached the following learning results		
<b>Professional Competence</b>				
Knowledge				
	Students are able			
	to describe and to explain surrent fabrication	on tachniques for Si and CaAs substrates		
	to describe and to explain current fabrication	on techniques for Si and GaAs substrates,	,	
		ication processes, process flows and t	the impact thereof o	n the fabrication (
	semiconductor devices and integrated circuits a	nd		
	• to present integrated process flows.			
Skills				
	Students are capable			
	to analyze the impact of process parameter	s on the processing results.		
		on the processing results,		
	to select and to evaluate processes and			
	to develop process flows for the fabrication of semiconductor devices.			
Personal Competence				
Social Competence				
	Students are able to plan and carry out exper	J 1 .		
	These social skills are practiced both during the			sent the theory, an
	during the follow-up phase, in which the groups	prepare, document and present their pra	actical experiences.	
Autonomy	The independence of the students is demanded	d and promoted in that they have to trar	nsfer and apply what t	they have learned t
,	ever new boundary conditions. This requiremen			
	the exam. Students are encouraged to work inc	dependently by not being given a solutio	n, but by learning to v	vork out the solutio
	step by step by asking specific questions. Stu		ntly when they are fa	ced with a problen
Wadded in Herre	They learn to independently break down proble			
Workload in Hours Credit points	Independent Study Time 96, Study Time in Lect	ure o4		
Course achievement				
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelect	ronics and Microsystems Technology: Ele	ctive Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Artificial			
	Biomedical Engineering: Specialisation Implants	·	•	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Manager	and and Duckers Advitation of the Electric	Camanala :	

Тур	Lecture
Hrs/wk	4
СР	4
	Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
Cycle	SoSe
Content	<ul> <li>Introduction (historical view and trends in microelectronics)</li> <li>Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects)</li> <li>Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone proce</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, h order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dam annealing and equipment)</li> <li>Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kininfluences 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 kine temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD technical APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vac</li> </ul>
	<ul> <li>Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proxi and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electroplating lithography, wet chemical etching: isotropic anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchacksputtering, 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 contents.</li> </ul>
	wire 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
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	The School of th

Course L0723: Semiconducto	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		

P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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			
Educational Objectives	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>			
	<ul> <li>Students learn to apply basic control con</li> </ul>	cepts for different tasks in humanoid ro	obotics.	
Skills	<ul> <li>Students acquire knowledge about select</li> </ul>	ted aspects of humanoid robotics, base	d on specified literature	
	<ul> <li>Students generalize developed results ar</li> </ul>	·		
	Students practice to prepare and give a	presentation		
Personal Competence				
Social Competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	<ul> <li>They are able to provide appropriate fee</li> </ul>	dback and handle constructive criticism	of their own results	
Autonomy				
natonomy	<ul> <li>Students evaluate advantages and dra</li> </ul>	wbacks of different forms of presenta	ation for specific tasks	and select the bes
	solution			
	Students familiarize themselves with a		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 System	s and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: El			
	Biomedical Engineering: Specialisation Artificial	•		
	Biomedical Engineering: Specialisation Implants	·	•	
	Biomedical Engineering: Specialisation Medical	•		
	Biomedical Engineering: Specialisation Manage			
	Theoretical Mechanical Engineering: Specialisat	ion Robotics and Computer Science: Eli	ective Compulsory	

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).

Module M0838: Linea	r and Nonlinear System Id	entifikation	
Courses			
Title		Тур	Hrs/wk CP
Linear and Nonlinear System Identi	fication (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>	ponse, root locus)	
	Discrete-time systems		
	Linear algebra, singular value d	lecomposition	
	Basic knowledge about stochas		
Educational Objectives	After taking part successfully, student	s have reached the following learning resu	Its
Professional Competence			
Knowledge	Students can explain the gene	ral framework of the prediction error me	thod and its application to a variety of linear and
	nonlinear model structures		
		er perceptron networks are used to model i	
		ximate predictive control scheme can be b	
	They can explain the idea of sull	bspace identification and its relation to Ka	man realisation theory
Skills			
	Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear  and the first invariance contains a second of the contains and the second of the		
	models for dynamic systems  They are capable of implement	ing a poplinear predictive control scheme	assed on a neural network model
	<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 systems</li> </ul>		
		andard software tools (including the Matla	
Personal Competence			
Social Competence	Students can work in mixed groups on	n specific problems to arrive at joint solutio	ns.
Autonomy	Students are able to find required info	ormation in sources provided (lecture note:	s, literature, software documentation) and use it to
	solve given problems.		
Workload in Hours	Independent Study Time 62, Study Tin	me in Lecture 28	
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and	30 min		
scale			
_		Control and Power Systems Engineering: E	
Following Curricula		at Systems and Robotics: Elective Compuls	ory
	Mechatronics: Specialisation System D	, ,	ina. Flashina Caranulaan
		n Artificial Organs and Regenerative Medic	· ·
		n Implants and Endoprostheses: Elective Co n Medical Technology and Control Theory:	
		n Management and Business Administratio	
		Core Qualification: Elective Compulsory	

Course L0660: Linear and No	onlinear 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>

	Тур	Hrs/wk	СР	
3)	Lecture	2	3	
)) 	Recitation Section (small)	2	3	
Prof. Herbert Werner				
None				
Classical control (frequency response, root log	cus)			
State space methods				
Linear algebra, singular value decomposition				
After taking part successfully, students have reache	d the following learning results			
	·			
	· ·		trainte	
	· ·			
They can explain how - based on the small g	ain theorem - a robust controller can gu	arantee stability	and performance	
an uncertain plant.				
They understand how analysis and synthesis	conditions on feedback loops can be repr	esented as linear	matrix inequalitie	
<ul> <li>Students are capable of designing and tuning</li> </ul>	LQG controllers for multivariable plant m	odels.		
	nfinity design problem in the form of a ge	neralized plant, a	nd of using stand	
· ·	-			
		loops into constr	aints on closed-it	
		. and of designin	g a mixed-object	
robust controller.		,		
They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of usin				
LMI-solvers for solving them.				
They can carry out all of the above using star	idard software tools (Matlab robust contro	ol toolbox).		
Students can work in small groups on specific proble	ems to arrive at joint solutions.			
		software documer	ntation) and use it	
solve given problems.				
Independent Study Time 124, Study Time in Lecture	56			
30 min				
Electrical Engineering: Specialisation Control and Po	wer Systems Engineering: Elective Comp	ulsory		
Aircraft Systems Engineering: Core Qualification: Ele	• •			
	RODOTICS: Elective Compulsory			
Mechatronics: Specialisation Intelligent Systems and	- Compulsory			
Mechatronics: Specialisation System Design: Elective		Compulsory		
Mechatronics: Specialisation System Design: Elective Biomedical Engineering: Specialisation Artificial Orga	ans and Regenerative Medicine: Elective	Compulsory		
Mechatronics: Specialisation System Design: Elective	ans and Regenerative Medicine: Elective ( Endoprostheses: Elective Compulsory			
Mechatronics: Specialisation System Design: Elective Biomedical Engineering: Specialisation Artificial Orga Biomedical Engineering: Specialisation Implants and	ans and Regenerative Medicine: Elective ( Endoprostheses: Elective Compulsory nology and Control Theory: Elective Com	pulsory		
Mechatronics: Specialisation System Design: Elective Biomedical Engineering: Specialisation Artificial Orga Biomedical Engineering: Specialisation Implants and Biomedical Engineering: Specialisation Medical Tech	ans and Regenerative Medicine: Elective of Endoprostheses: Elective Compulsory nology and Control Theory: Elective Com and Business Administration: Elective Co	pulsory		
Mechatronics: Specialisation System Design: Elective Biomedical Engineering: Specialisation Artificial Orga Biomedical Engineering: Specialisation Implants and Biomedical Engineering: Specialisation Medical Tech Biomedical Engineering: Specialisation Management	ans and Regenerative Medicine: Elective of Endoprostheses: Elective Compulsory nology and Control Theory: Elective Com and Business Administration: Elective Co ecialisation Product Development: Elective ecialisation Production: Elective Compulso	pulsory ompulsory e Compulsory ory		
	Prof. Herbert Werner  None  Classical control (frequency response, root loce State space methods Linear algebra, singular value decomposition  After taking part successfully, students have reache  Students can explain the significance of the new they can explain the duality between optimale they can explain how the H2 and H-infinity new they can explain how an LQG design problem they can explain how model uncertainty cane they can explain how an advertainty cane they can explain how an advertainty cane they can explain how an algorithm to the small of the same they can explain how analysis and synthesis they are capable of designing and tuning they are capable of representing a H2 or H-insoftware tools for solving it.  They are capable of translating time and fresensitivity functions, and of carrying out a mixed tools to they are capable of constructing an LFT unconstruction to the sensitivity functions, and of carrying out a mixed tools to the solvers for solving them.  They are capable of formulating analysis and LMI-solvers for solving them.  They can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they can carry out all of the above using stand they carried t	Prof. Herbert Werner  None  Classical control (frequency response, root locus) State space methods Linear algebra, singular value decomposition  After taking part successfully, students have reached the following learning results  Students can explain the significance of the matrix Riccati equation for the solution of They can explain the duality between optimal state feedback and optimal state estima They can explain how the H2 and H-infinity norms are used to represent stability and p They can explain how model uncertainty can be represented in a way that lends itself They can explain how - based on the small gain theorem - a robust controller can gu an uncertain plant.  They understand how analysis and synthesis conditions on feedback loops can be represented in a vary that lends itself or they are capable of designing and tuning LQG controllers for multivariable plant m They are capable of representing a H2 or H-infinity design problem in the form of a ge software tools for solving it.  They are capable of translating time and frequency domain specifications for control sensitivity functions, and of carrying out a mixed-sensitivity design.  They are capable of constructing an LFT uncertainty model for an uncertain system robust controller.  They are capable of formulating analysis and synthesis conditions as linear matrix ine LMi-solvers for solving them.  They are capable of formulating analysis and synthesis conditions as linear matrix ine LMi-solvers for solving them.  They can carry out all of the above using standard software tools (Matlab robust control students can work in small groups on specific problems to arrive at joint solutions.  Students can work in small groups on specific problems to arrive at joint solutions.  Students are able to find required information in sources provided (lecture notes, literature, solve given problems.	Prof. Herbert Werner  None  Classical control (frequency response, root locus) State space methods Linear algebra, singular value decomposition  After taking part successfully, students have reached the following learning results  Students can explain the significance of the matrix Riccati equation for the solution of LQ problems. They can explain the duality between optimal state feedback and optimal state estimation. They can explain how the H2 and H-infinity norms are used to represent stability and performance constants. They can explain how an LQG design problem can be formulated as special case of an H2 design problem. They can explain how anded uncertainty can be represented in a way that lends itself to robust controll. They can explain how a based on the small gain theorem - a robust controller can guarantee stability an uncertain plant. They understand how analysis and synthesis conditions on feedback loops can be represented as linear. Students are capable of designing and tuning LQG controllers for multivariable plant models. They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, a software tools for solving it. They are capable of translating time and frequency domain specifications for control loops into constructing an LFT uncertainty model for an uncertain system, and of designing robust controller. They are capable of formulating an LFT uncertainty model for an uncertain system, and of designing robust controller. They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), at LMI-solvers for solving them. They can carry out all of the above using standard software tools (Matlab robust control toolbox).  Students are able to find required information in sources provided (lecture notes, literature, software documer solve given problems.	

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

Course L0659: Optimal and F	urse 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				
Knowledge	Module International Business     Basic understanding of business administration p	rinciples (strategic planning decision	on theory pro	iect management
	international business)	miciples (strategic planning, decision	on theory, pro	ject management,
	Bachelor-level Marketing Knowledge (Marketing Instr	uments, Market and Competitor Strat	egies, Basics of	Buying Behavior)
	Unerstanding the differences beweetn B2B and B2C r		3,	, , ,
	Understanding of the importance of managing innova-	ation in global industrial markets		
	Good English proficiency; presentation skills			
Educational Objectives	After taking part successfully, students have reached the fo	llowing learning results		
		nowing learning results		
Professional Competence  Knowledge				
Knowieuge	Statents will have gained a deep understanding of			
	Specific characteristics in the marketing of innovative	e poroducts and services		
	Approaches for analyzing the current market situatio		t	
	The gathering of information about future customer r			
	Concepts and approaches to integrate lead users and     Approaches and tools for onsuring sustamer orientations.			
	<ul> <li>Approaches and tools for ensuring customer-orientation</li> <li>Marketing mix elements that take into consideration</li> </ul>			
	services	the specific requirements and chair	icinges of filliov	ative products and
	Pricing methods for new products and services			
	The organization of complex sales forces and personal	al selling		
	Communication concepts and instruments for new pr	oducts and services		
Skills	Based on the acquired knowledge students will be able to:			
	Design and to evaluate decisions regarding marketing	g and innovation strategies		
	Analyze markets by applying market and technology			
	Conduct forecasts and develop compelling scenarios	as a basis for strategic planning		
	Translate customer needs into concepts, prototypes	and marketable offers and successf	fully apply adva	anced methods for
	customer-oriented product and service development			
	Use adequate methods to foster efficient diffusion of	innovative products and services		
	Choose suitable pricing strategies and communicatio			
	Make strategic sales decisions for products and service      Apply methods of sales force management (i.e. such			
	Apply methods of sales force management (i.e. custo	imer value analysis)		
Personal Competence				
Social Competence	The students will be able to			
	have fruitful discussions and exchange arguments			
	develop original results in a group			
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
	a Acquire Impulsed as independent to the country	out and to man this line of the control	har ne	w problem 6:101
	<ul> <li>Acquire knowledge independently in the specific cont</li> <li>Consider proposed business actions in the field of ma</li> </ul>	,	ner new compie	x problem fields.
	Consider proposed business decions in the field of file	incerning and reneet on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement				
	Subject theoretical and practical work			
Examination duration and		tion		
scale			Comm. Inc.	
Assignment for the		•		
Following Curricula	International Management and Engineering: Specialisation I Mechanical Engineering and Management: Specialisation Ma		привогу	
	Biomedical Engineering and Management: Specialisation Ma Biomedical Engineering: Specialisation Artificial Organs and		npulsory	
	Biomedical Engineering: Specialisation Implants and Endopr			
	Biomedical Engineering: Specialisation Medical Technology		sory	
	Biomedical Engineering: Specialisation Management and Bu			

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 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			

	ocess Engineering - Fundamenta			
Courses				
Γitle		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame	ntals (L0841)	Lecture	2	3
Bioprocess Engineering- Fundamer	ntals (L0842)	Recitation Section (large)	2	1
Bioprocess Engineering - Fundame	ntal Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
<b>Recommended Previous</b>	module "organic chemistry", module "fundame	ntals for process engineering"		
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 to describe the basic concep	ts of bioprocess engineering. They are able	to classify differen	t types of kinetics
	enzymes and microorganisms, as well as to	differentiate different types of inhibition.	The parameters of	of stoichiometry
	rheology can be named and mass transport	processes in bioreactors can be explained	l. The students are	e capable to exp
	fundamental bioprocess management, steriliza	tion technology and downstream processing	in detail.	
Skills	After successful completion of this module, stu	dents should be able to		
	describe different kinetic approaches for	growth and substrate-uptake and to calcula	te the correspondir	ng narameters
		nergy generation, regeneration of redox ed		
	fermentation process	lengy generation, regeneration of ready ed	jarvarenes and gro	Well minibilion on
	'	ometry and to set up / solve metabolic flux e	quations	
	· ·	different bioreactors and bioprocesses (ana	•	well as microaero
	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 procedure	es as well as results in a scientific manner		
Damanal Camanahanaa				
Personal Competence	AG	. It has also to delicate to the death of a state of the second		
Social Competence				
	take position to their own opinions and increase	e their capacity for teamwork in engineering	and scientific envi	ronments.
Autonomy	After completion of this module participants w	ill be able to solve a technical problem in a	team independentl	ly by organizing tl
	workflow and to present their results in a plent	ım.		
	Independent Study Time 96, Study Time in Lec	ture 84		
Credit points	Compulsory Bonus Form	Description		
Course achievement	Yes 5% Subject theoretical	and		
	practical work			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Bioprocess Engineering: Core Qualification: Cor	npulsory		
Following Curricula	Green Technologies: Energy, Water, Climate: S	• •	ve Compulsory	
, <b>,</b> ,	Biomedical Engineering: Specialisation Artificia	3,	, ,	
	Biomedical Engineering: Specialisation Implant		-	
	Biomedical Engineering: Specialisation Medical	· · ·	mpulsory	
	Biomedical Engineering: Specialisation Manage			
	Technomathematics: Specialisation III. Enginee		• •	
	Process Engineering: Core Qualification: Compu			

Course L0841: Bioprocess En	igineering - 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
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out.  The students document their experiments and results in a protocol.
Literature	Skript

Module M1143: Applie	ed Design Methodology in Mechatronic	cs		
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 compu	ter-sciences		
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	Science-based working on interdisciplinary product design	gn considering targeted application of sp	ecific product	design techniques
Skills	Creative handling of processes used for scientific prepar	ration and formulation of complex produc	t design prob	olems / Application of
	various product design techniques following theoretical	aspects.		
Personal Competence				
Social Competence	Students will solve and execute technical-scientific ta	sks from an industrial context in small	design-teams	s with application of
	common, creative methodologies.	common, creative methodologies.		
Autonomy	Students are enabled to optimize the design and development process according to the target and topic of the design			e design
	Students are educated to operate in a development teal	m		
	Students learn about the right application of creative me	ethods in engineering.		
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: Specialisati	on II. Product Development and Production	n: Elective C	ompulsory
Following Curricula	International Management and Engineering: Specialisati	on II. Mechatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation	n Product Development and Production: E	lective Comp	ulsory
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and Eng	loprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology	gy and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation Produ	uct Development 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	Course L1524: Applied Design Methodology in Mechatronics		
Тур	Project-/problem-based Learning		
Hrs/wk	3		
СР	4		
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42		
Lecturer	Prof. Thorsten Kern		
Language	EN		
Cycle	SoSe		
Content	See interlocking course		
Literature	See interlocking course		

Courses				
Title		Тур	Hrs/wk	CP
Introduction to Anatomy (L0384)		Lecture	2	3
Module Responsible	Prof. Udo Schumacher			
Admission Requirements	None			
	Students can listen to the lectures without any prior	knowledge. Basic school kno	wledge of biology, chem	istry / biochemist
Knowledge	physics and Latin can be useful.			
<b>Educational Objectives</b>	After taking part successfully, students have reached th	e following learning results		
Professional Competence				
Knowledge	The lectures are about microscopic anatomy, describin	the microscopic structure of	of tissues and organs, and	d about macrosco
	anatomy which is about organs and organ systems. The	lectures also contain an int	roduction to cell biology,	human developm
	and to the central nervous system. The fundamentals	of radiologic imaging are de	escribed as well, using pr	ojectional x-ray a
	cross-sectional images. The Latin terms are introduced.			
Ckilla	At the and of the lecture series the students are able	to describe the microscop	is as well as the masses	canic accombly
SKIIIS	At the end of the lecture series the students are able functions of the human body. The Latin terms are the p			
	understand und further develop medical devices.	rerequisite to understand int	edical literature. This kno	wieuge is fieeded
	understand und further develop medical devices.			
	These insights in human anatomy are the fundament	als to explain the role of st	ructure and function for	the development
	common diseases and their impact on the human body. $ \\$			
Personal Competence				
Social Competence	The students can participate in current discussions in ${\bf k}$	iomedical research and med	licine on a professional le	vel. The Latin te
	are prerequisite for communication with physicians on a	professional level.		
Autonomy	The lectures are an introduction to the basics of ar	atomy and should encourag	ge students to improve	their knowledge
	themselves. Advice is given as to which further litera	ture is suitable for this purp	ose. Likewise, the lectur	e series encoura
	students to recognize and think critically about biomedic	al problems.		
	Independent Study Time 62, Study Time in Lecture 28			
Credit points  Course achievement				
Examination				
Examination duration and scale	90 minutes			
Assignment for the	General Engineering Science (German program, 7 seme	ter): Specialisation Biomedic	al Engineering: Compulse	NEV/
Following Curricula	General Engineering Science (German program, 7 series	•		•
y caa	Compulsory	cinester, specialisation in	zenamear Engineering, i	ocas Bioinicenan
	Data Science: Specialisation II. Application: Elective Con	pulsory		
	Electrical Engineering: Specialisation Medical Technolog			
	Engineering Science: Specialisation Biomedical Engineer			
	General Engineering Science (English program, 7 semes	, ,	al Engineering: Compulsor	ту
	Mechanical Engineering: Specialisation Biomechanics: C			
	Biomedical Engineering: Specialisation Medical Technology	, ,	ive Compulsory	
	Biomedical Engineering: Specialisation Management and			
	Biomedical Engineering: Specialisation Artificial Organs			
	Biomedical Engineering: Specialisation Implants and Eng	oprostheses: Elective Compu	ulsory	
	Technomathematics: Specialisation III. Engineering Scie	sor Floctive Compulsory		

Course L0384: Introduction t	o Anatomy	
Тур	Lecture	
Hrs/wk	2	
СР	3	
		Time 62, Study Time in Lecture 28
	Prof. Tobias Lange	
Language		
Cycle		
Content	General Anatomy	
	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
1:4	Adolf Follow/Mi-b	J Cabillaka Dar Körner des Manschen 17 Auflage Thioma Verlag Chuttaget 2016
Literature	Adolf Faller/Michae	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

. IJudio PILZ/OI PIED	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	
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	
Knowledge	<b>Therapy</b> 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.
<b>Personal Competence</b>	
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	3
Course achievement	
	Written exam
Examination duration and scale	ao minures
Assignment for the Following Curricula	
	Data Science: Specialisation II. Application: Elective 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 t	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 M1280: MED I	II: Introduction to Physiology
Courses	
Title	Typ Hrs/wk CP
Introduction to Physiology (L0385)	Lecture 2 3
Module Responsible	Dr. Roger Zimmermann
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe the basics of the energy metabolism;
	<ul> <li>describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.</li> </ul>
G	
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, developmen
Davisanal Compatones	of forces and vital functions) and relate them to similar technical systems.
Personal Competence	The students can conduct discussions in research and medicine on a technical level.
Social Competence	The students can find solutions to problems in the field of physiology, both analytical and metrological.
	The state has can mile solutions to prosterior in the near or prijosology) social analysical and metrological
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, b
	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	
•	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics
	Compulsory  Data Sciences Specialization Medicines Compulsors
	Data Science: Specialisation Medicine: Compulsory  Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	Engineering: Specialisation Medical Technology: Elective Compulsory  Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0385: Introduction t	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 M1335: BIO II	l: Artificial Joint Replacement	
Courses		
Title	Typ Hrs/wk CP	
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 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 name the different kinds of artificial limbs.	
Chille	The students can explain the advantages and disadvantages of different kinds of endoprotheses.	
SKIIIS	The students can explain the advantages and disadvantages of different kinds of endoprotrieses.	
Personal Competence		
Social Competence	The students are able to discuss issues related to endoprothese with student mates and the teachers.	
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibilit	h.,
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility	Ly.
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	
	Orientation Studies: Core Qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective 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: Feedl	back Control in Medical Tech	inology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
<b>Recommended Previous</b>	Basics in Control, Basics in Physiology			
Knowledge				
<b>Educational Objectives</b>	After taking part successfully, students h	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.			
	Internal control loops of the human boo example in for anesthesia control.	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system fo example in for anesthesia control.		
	The handling of PID controllers and mo- illustrated. The operation of simple equiv	odern controller like predictive controller or fuz valent circuits will be discussed.	zzy controller or neu	ral networks will be
Skills	Application of modeling, identification, co	ontrol technology in the field of medical technolog	gy.	
Personal Competence Social Competence	Students can develop solutions to specifi	c problems in small groups and present their res	ults	
Autonomy	· ·	ature and to set it into the context of the lecture their learning process. They can combine known	•	•
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Med	dical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Cor	ntrol and Power Systems Engineering: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsor	y	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Electi	ive Compulsory	
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Elective	e Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Compulso	ory	

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> </ul> Techniques of modeling, simulation and controller development are discussed. In the models, simple equivalent block diagrams for physiological processes are derived and explained how sensors, controllers and actuators are operated. MATLAB and SIMULINK are		
Literature	used as development tools.  • Leonhardt, S., & Walter, M. (2016). Medizintechnische Systeme. Berlin, Heidelberg: Springer Vieweg.		
	<ul> <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: Medi	Car recimology Eab
Courses	
Title	Typ Hrs/wk CP
Medical Technology Lab (L1096)	Project-/problem-based Learning 6 6
Module Responsible	
Admission Requirements	
Kecommended Previous Knowledge	sound programming skills (Java / C++) skills in R/Matlab
Kilowicage	knowledge of image processing
	principles of math (algebra, analysis/calculus)
	principles of stochastics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students recognize the complexity of medical technology and can explain, which methods are appropriate to solve a probler
	at hand.
Skills	The students are able to analyze and solve problems in medical technology.
Personal Competence	
•	The students are able to conceptualize project goals in groups and organize the project process, taking into account a reasonab
Social competence	distribution of tasks within the group.
	The students are able to define and fill different roles within the group for the task at hand and are able to contribute to the group for the gro
	process according to that role.
	They can lead group processes responsibly and are able to develop ways of dealing with problems in the group and in the wo
	process.  The students are able to collaboratively organize their work processes and software solutions using virtual communication an
	software management tools (e.g., GitLab, Mattermost).
Autonomy	The students can independently develop solution strategies and adapt these when problems arise in the course of the project.
	The students can assess their level of knowledge and document their work results. They can critically evaluate the results achieve and present them to the target group in an appropriate manner.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	
Examination	Yes None Group discussion  Written elaboration
Examination duration and	
scale	
Assignment for the	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
Following Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

Course 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 M1384: Case	Studies for Regenerative Medicine and Tissue Engineering			
Courses				
Title	Typ Hrs/wk CP			
Case Studies for Regenerative Med	licine and Tissue Engineering (L1963) Seminar 3 6			
Module Responsible	Prof. Ralf Pörtner			
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	After successfully participating in the module case studies on regenerative medicine and tissue engineering, the students			
	can recognize, how a team works together to work on a complex task			
	<ul> <li>can assign, which planning tools are required for new cell-based therapy concepts and medical products from the "proof-of-</li> </ul>			
	concept" to successful market approval			
	can illustrate, which obstacles and difficulties arise during the market approval of the concepts and products mentioned			
Skills	After successful completion of the module students are			
	able to use relevant 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 analyse and evaluate current research topics and applications for Tissue Engineering and Regenerative Medicine.			
Personal Competence				
•	Students are able to work together as a team with 6-8 students to solve given tasks and discuss their results in the plenary and to			
,	defend them.			
	Students are able to reflect their work orally and discuss it with other students and teachers.			
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 6-8 persons			
	independently			
	including a presentation of the results.			
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 Artificial Organs and Regenerative Medicine: Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

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	The students should work in working groups to develop concepts for the path from "proof of concept" to successful market approval for new cell-based therapy concepts and medical products. It is assumed that an initial test phase was successful for the respective concepts. A routine clinical application must now be established in each case. Strategies are to be developed for this.
Literature	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540

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	given problems.  Independent Study Time 124, Study Time in Lecture 56		
Credit points			
Course achievement			
Examination			
Examination duration and			
scale			
Assignment for the			
Following Curricula			
	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	V	
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	ectromagnetics	: Principles and	d Applications			
Courses						
Title				Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and Applications (L0371)				Lecture	3	5
Bioelectromagnetics: Principles and Applications (L0373)				Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuste	Prof. Christian Schuster				
Admission Requirements	None					
Recommended Previous	Basic principles of phy	/sics				
Knowledge						
Educational Objectives	After taking part succ	essfully, students hav	e reached the followi	ng learning results		
<b>Professional Competence</b>						
Knowledge	Students can explain	the basic principles, re	elationships, and met	hods of bioelectromagnetics,	i.e. the quantifica	ation and application
	_	•	•	and exemplify the most impo		
		-		s. They can give an overvie		
	·			actical applications . They ca	in give examples	for therapeutic ar
	diagnostic utilization of	or electromagnetic fiel	ids in medical techno	logy.		
Skills	Students know how to	annly various metho	ds to characterize the	e behavior of electromagnetic	r fields in hiologic	altissue In order
Skills				lutions of Maxwell's Equation		
	,		•	ue, they can order the effec	•	
				tative way. They are able to		
	predictions. They are	able to evaluate the e	ffects of electromagr	netic fields for therapeutic an	d diagnostic appli	cations and make
	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 sr	nall group exercises).				
4	Charlents are sensible		furur			
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					
		•		ntals of electrical engineering		
	problems and effects	,		-	ig / physics). The	y can commune
Workload in Hours	Independent Study Tir	me 110, Study Time ir	n Lecture 70			
Credit points		-				
Course achievement	Compulsory Bonus	Form	Description			
	Yes None	Presentation				
Examination	Oral exam					
Examination duration and	45 min					
scale						
Assignment for the	Electrical Engineering	: Specialisation Microv	vave Engineering, On	otics, and Electromagnetic Co	mpatibility: Electi	ve Compulsorv
Following Curricula		•	3 3. 1		,, . Electi	
3				ectrical Engineering: Elective	Compulsory	
	_		•	ss Administration: Elective Co		
	Biomedical Engineerin	g: Specialisation Impl	ants and Endoprosth	eses: Elective Compulsory		
	Biomedical Engineerin	ng: Specialisation Artif	icial Organs and Reg	enerative Medicine: Elective	Compulsory	
	Biomedical Engineerin	ng: Specialisation Med	ical Technology and (	Control Theory: Elective Com	pulsory	
	Theoretical Mechanica	al Engineering: Specia	lisation Bio- and Med	ical Technology: Elective Con	npulsory	

Course L0371: Bioelectromag	gnetics: Principles and Applications			
Тур	Lecture			
Hrs/wk	3			
СР				
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42			
	of. Christian Schuster			
Language	E/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)			

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

## Thesis

Module M1801: Maste	er thesis (dual study program)	
Courses		
Title	Typ Hrs/wk CP	
Module Responsible	Professoren der TUHH	
Admission Requirements		
Recommended Previous		
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
<b>Professional Competence</b>		
Knowledge	Dual students	
Skills	<ul> <li> use the specialised knowledge (facts, theories and methods) from their field of study and the acquired professional knowledge confidently to deal with technical and practical professional issues.</li> <li> can explain the relevant approaches and terminologies in depth in one or more of their subject's specialist areas, describe current developments and take a critical stance.</li> <li> formulate their own research assignment to tackle a professional problem and contextualise it within their subject area. They ascertain the current state of research and critically assess it.</li> <li>Dual students</li> <li> can select suitable methods for the respective subject-related professional problem, apply them and develop them further as required.</li> <li> assess knowledge and methods acquired during their studies (including practical phases) and apply their expertise to complex and/or incompletely defined problems in a solution- and application-oriented manner.</li> </ul>	
Personal Competence	acquire new academic knowledge in their subject area and critically evaluate it.	
Social Competence	Dual students	
Autonomy	<ul> <li> can present a professional problem in the form of an academic question in a structured, comprehensible and factually correct manner, both in writing and orally, for a specialist audience and for professional stakeholders.</li> <li> answer questions as part of a professional discussion in an expert, appropriate manner. They represent their own points of view and assessments convincingly.</li> <li>Dual students</li> </ul>	
	<ul> <li> can structure their own project into work packages, work through them at an academic level and reflect on them with regard to feasible courses of action for professional practice.</li> <li> work in-depth in a partially unknown area within the discipline and acquire the information required to do so.</li> <li> apply the techniques of academic work comprehensively in their own research work when dealing with an operational problem and question.</li> </ul>	
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0	
Credit points	30	
Course achievement	None	
Examination	Thesis	
Examination duration and	According to General Regulations	
scale		
Assignment for the		
Following Curricula	Bioprocess Engineering: Thesis: Compulsory  Chemical and Bioprocess Engineering: Thesis: Compulsory	
	Computer Science: Thesis: Compulsory	
	Electrical Engineering: Thesis: Compulsory	
	Energy Systems: Thesis: Compulsory	
	Environmental Engineering: Thesis: Compulsory	
	Aircraft Systems Engineering: Thesis: Compulsory	
	Computer Science in Engineering: Thesis: Compulsory	
	Information and Communication Systems: Thesis: Compulsory	
	International Management and Engineering: Thesis: Compulsory	
	Logistics, Infrastructure and Mobility: Thesis: Compulsory  Materials Science: Thesis: Compulsory	
	Materials Science: Thesis: Compulsory  Mechanical Engineering and Management: Thesis: Compulsory	
	Mechatronics: Thesis: Compulsory	
	Biomedical Engineering: Thesis: Compulsory	
	Microelectronics and Microsystems: Thesis: Compulsory	
	Product Development, Materials and Production: Thesis: Compulsory	
	Renewable Energies: Thesis: Compulsory	
	Naval Architecture and Ocean Engineering: Thesis: Compulsory	
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Theoretical Mechanical Engineering: Thesis: Compulsory
Process Engineering: Thesis: Compulsory
Water and Environmental Engineering: Thesis: Compulsory