



Module Manual

Master of Science (M.Sc.)

Biomedical Engineering

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Program description

Content

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

Career prospects

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

Learning target

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

Graduates are able to:

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

Core Qualification

Module M0523: Business & Management

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

Courses

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

Module M0524: Non-technical Courses for Master	
Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence <i>Knowledge</i>	<p>The Nontechnical Academic Programms (NTA)</p> <p>imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its teaching architecture, in its teaching and learning arrangements, in teaching areas and by means of teaching offerings in which students can qualify by opting for specific competences and a competence level at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.</p> <p>The Learning Architecture</p> <p>consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.</p> <p>The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".</p> <p>The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.</p> <p>Teaching and Learning Arrangements</p> <p>provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.</p> <p>Fields of Teaching</p> <p>are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, communication studies, migration studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way.</p> <p>The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.</p> <p>The Competence Level</p> <p>of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.</p> <p>This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.</p> <p>Specialized Competence (Knowledge)</p> <p>Students can</p> <ul style="list-style-type: none"> • explain specialized areas in context of the relevant non-technical disciplines, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Professional Competence <i>Skills</i>	<p>Professional Competence (Skills)</p> <p>In selected sub-areas students can</p> <ul style="list-style-type: none"> • apply basic and specific methods of the said scientific disciplines, • question a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple and advanced questions in aforementioned scientific disciplines in a successful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.

<p>Personal Competence <i>Social Competence</i></p>	<p>Personal Competences (Social Skills)</p> <p>Students will be able</p> <ul style="list-style-type: none"> • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
<p><i>Autonomy</i></p>	<p>Personal Competences (Self-reliance)</p> <p>Students are able in selected areas</p> <ul style="list-style-type: none"> • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in written form or verbally • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
<p>Workload in Hours</p>	<p>Depends on choice of courses</p>
<p>Credit points</p>	<p>6</p>

Courses

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

Module M1173: Applied Statistics				
Courses				
Title		Typ	Hrs/wk	CP
Applied Statistics (L1584)		Lecture	2	3
Applied Statistics (L1586)		Project-/problem-based Learning	2	2
Applied Statistics (L1585)		Recitation Section (small)	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of statistical methods			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<i>Knowledge</i> Students can explain the statistical methods and the conditions of their use. <i>Skills</i> Students are able to use the statistics program to solve statistics problems and to interpret and depict the results			
Personal Competence	<i>Social Competence</i> Team Work, joined presentation of results <i>Autonomy</i> To understand and interpret the question and solve			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Written elaboration	
Examination	Written exam			
Examination duration and scale	90 minutes, 28 questions			
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			
Course L1584: Applied Statistics				
Typ	Lecture			
Hrs/wk	2			
CP	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: <ul style="list-style-type: none"> • 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 categorical data • Choosing 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	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.
Literature	Selbst zu finden

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

Module M0811: Medical 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 Knowledge	none		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i>	<p>Students can:</p> <ul style="list-style-type: none"> 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; <p>Describe and explain the main clinical uses of the different systems.</p>		
<i>Skills</i>	<p>Students are able to:</p> <ul style="list-style-type: none"> Explain the physical processes of images and assign to the systems the basic mathematical or physical equations required; <ul style="list-style-type: none"> Calculate the parameters of imaging systems using the mathematical or physical equations; Determine the influence of different system components on the spatial and temporal resolution of imaging systems; Explain the importance of different imaging systems for a number of clinical applications; <p>Select a suitable imaging system for an application.</p>		
Personal Competence <i>Social Competence</i>	none		
<i>Autonomy</i>	<p>Students can:</p> <ul style="list-style-type: none"> Understand which physical effects are used in medical imaging; Decide independently for which clinical issue a measuring system can be used. 		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	<p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory 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</p>		

Course L0819: Medical Imaging Systems	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dr. Michael Grass, Dr. Tim Nielsen, Dr. Sven Prevrhal, Frank Michael Weber
Language	DE
Cycle	SoSe
Content	
Literature	<p>Primary book:</p> <p>1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press</p> <p>Secondary books:</p> <ul style="list-style-type: none"> - A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003. - W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002. - H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995. - O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.

Module M1179: Medical Basics and Pathology			
Courses			
Title	Typ	Hrs/wk	CP
Medical Basics and Pathology I (L1599)	Lecture	2	2
Medical Basics and Pathology II (L1600)	Lecture	2	2
Medical Basics and Pathology III (L1602)	Lecture	2	2
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	120 minutes		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Biomedical Engineering: Core Qualification: Compulsory		

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

Course L1600: Medical Basics and Pathology II	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Johannes Kluwe
Language	DE
Cycle	WiSe
Content	<p>Major diseases of</p> <ul style="list-style-type: none"> • the gastrointestinal system and the liver, • the hormone system, • the kidneys. <p>The lecture will focus on pathophysiology, symptoms, diagnostic and therapeutic principles of these diseases.</p> <p>I Gastrointestinal tract and liver:</p> <ul style="list-style-type: none"> • Gastrointestinal bleeding: causes, symptoms, endoscopic treatment options • Colorectal cancer: basics, principle of prophylactic screening, therapy • Liver diseases / liver cirrhosis: causes, symptoms, complications, therapeutic options <p>II Hormones:</p> <ul style="list-style-type: none"> • Diabetes mellitus type 1 and 2: pathophysiology, complications, basics of glucose metabolism, therapeutic principles • Thyreoid gland - hyper- and hypothyreoidism: causes, symptoms diagnostics, therapy <p>III Kidneys</p> <ul style="list-style-type: none"> • Functions and failure, diagnostics, principles of renal replacement therapy
Literature	Wird in der Veranstaltung bekannt gegeben

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

Module M1164: Practical Course Product Development, Materials and Production				
Courses				
Title	Typ	Hrs/wk	CP	
Practical Course Product Development, Materials and Production (L1566)	Practical Course	6	6	
Module Responsible	Prof. Wolfgang Hintze			
Admission Requirements	None			
Recommended Previous Knowledge	<p>Product Development:</p> <ul style="list-style-type: none"> Lectures: Mechanics I-III Lectures: Integrated Product Development I incl. CAD practical training <p>Materials:</p> <ul style="list-style-type: none"> Lectures: Structural Metallic Materials, Metallic Materials for Aircraft Applications, Introduction to Materials Testing Lectures: Structure and Properties of Polymers, Structure and Properties of Composites, Manufacturing of Polymers and Composites <p>Production:</p> <ul style="list-style-type: none"> Lecture: Production Engineering Lectures: Forming and Cutting Technology, Methods of production process design Lectures: Machine Tools and Robotic 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can ...			
	<ul style="list-style-type: none"> represent more complex context of different fields of study. describe functionality of modern measurement instrumentations and machine technologies. 			
<i>Skills</i>	Students are capable of ...			
	<ul style="list-style-type: none"> applying theoretical knowledge for practical applications. applying provided experimental methods for examining contexts of different fields of study. analyzing and evaluating experimental results by using provided methods. applying modern measurement instrumentations. 			
Personal Competence				
<i>Social Competence</i>	Students can ...			
	<ul style="list-style-type: none"> carry out and document experimental work in groups. present and discuss experimental results in mixed teams of different fields of study. 			
<i>Autonomy</i>	Students are able to ...			
	<ul style="list-style-type: none"> carry out parts of experimental work independently guided by teachers. choose and apply suitable instruments. assess own strengths and weaknesses. 			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale				
Assignment for the Following Curricula	Biomedical Engineering: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Compulsory			

Course L1566: Practical Course Product Development, Materials and Production	
Typ	Practical Course
Hrs/wk	6
CP	6
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Lecturer	Prof. Wolfgang Hintze, Prof. Josef Schlattmann, Prof. Dieter Krause, Prof. Claus Emmelmann, Prof. Bodo Fiedler, Prof. Hermann Lödging, Prof. Michael Morlock, Prof. Gerold Schneider, Prof. Thorsten Schüppstuhl, Prof. Otto von Estorff, Prof. Jörg Weißmüller
Language	DE
Cycle	SoSe
Content	<p>Product Development:</p> <ul style="list-style-type: none"> • Modal analysis - experimental and computational • Appropriate design in engineering • Characterization of rubbery-elastic materials • Stick-Slip-Analysis at friction and wear test station <p>Materials:</p> <ul style="list-style-type: none"> • Property profiles of steel • Actuators for modern fuel injection systems - synthesis and properties • Processing, properties and structure of thermoplastic polymers and its composites • Tribology in joints <p>Production:</p> <ul style="list-style-type: none"> • Optimization of welding process parameters for hybrid plasma laser welding • Evaluation of stock removal processes • Analysis of basic laws in production logistics • Analysis of positioning behaviour and trajectory accuracy of industrial robots
Literature	Nach Themenstellung / depending on topic

Module M1180: Case Studie and Clinical Internship				
Courses				
Title		Typ	Hrs/wk	CP
Casestudies Surgery and Internal Medicine (L1603)		Seminar	5	5
Clinical Internship (L1587)		Practical Course	1	1
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	The lectures addressing medical issues from the concentration Biomedical Engineering in the respective BSc Programs.			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students learn the process of clinical practice regarding medical history, diagnosis and treatment decision with representative surgical and medical diseases in the various departments, and get an insight into the daily patient care through case studies in a hospital.			
<i>Skills</i>	Interpreting and explaining the medical history and medical records of a patient. Dealing with patients.			
Personal Competence				
<i>Social Competence</i>	Dealing with patients.			
<i>Autonomy</i>				
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale	5 Pages (10 Case studies)			
Assignment for the Following Curricula	Biomedical Engineering: Core Qualification: Compulsory			

Course L1603: Casestudies Surgery and Internal Medicine	
Typ	Seminar
Hrs/wk	5
CP	5
Workload in Hours	Independent Study Time 80, Study Time in Lecture 70
Lecturer	Dr. Dominic Wichmann, Dr. Johannes Kluwe
Language	DE
Cycle	WiSe/SoSe
Content	Die Fallstudien werden in einem 2-wöchentlichen Blockkurs in der Innere und Chirurgie demonstriert. Alle 1-2 Tage wechseln die Stationen hierzu gehören: <ul style="list-style-type: none"> - Notaufnahme - Intensivstation - Pneumologie - Gastroenterologie - Kardiologie - Transfusionsmedizin - Poliklinik/Ambulanz - Dialyse - Unfallchirurgie
Literature	keine spezifische

Course L1587: Clinical Internship	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe/SoSe
Content	<p>The students complete a 1-week clinical internship in a hospital.</p> <p>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.</p>
Literature	keine

Module M1214: Study work				
Courses				
Title	Typ	Hrs/wk	CP	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Subjects of the Master program and the specialisations.			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain the project as well as their autonomously gained knowledge and relate it to current issues of their field of study. • They can explain the basic scientific methods they have worked with. 			
<i>Skills</i>	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				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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 scale	according to FSPO			
Assignment for the Following Curricula	Biomedical Engineering: Core Qualification: Compulsory			

Specialization Implants and Endoprostheses

Module M0623: Intelligent Systems in Medicine

Courses

Title	Typ	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)	Lecture	2	3
Intelligent Systems in Medicine (L0334)	Project Seminar	2	2
Intelligent Systems in Medicine (L0333)	Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of stochastics • principles of programming, Java/C++ and R/Matlab • advanced programming skills 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.</p> <p><i>Skills</i> The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.</p> <p>Personal Competence</p> <p><i>Social Competence</i> The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.</p> <p><i>Autonomy</i> The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.</p>		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	Compulsory	Bonus	Form
	Yes	10 %	Written elaboration
	Yes	10 %	Presentation
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory 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 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 Bio- and Medical Technology: Elective Compulsory		

Course L0331: Intelligent Systems in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - methods for search, optimization, planning, classification, regression and prediction in a clinical context - representation of medical knowledge - understanding challenges due to clinical and patient related data and data acquisition <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	<p>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</p>

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

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

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)			
Courses			
Title	Typ	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomechanics (L0377)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Depends on choice of courses		
Credit points	6		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory		
Course L1663: Nature's Hierarchical Materials			
Typ	Seminar		
Hrs/wk	2		
CP	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and scale			
Lecturer	Prof. Gerold Schneider		
Language	EN		
Cycle	WiSe		
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc. This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.		
Literature	Peter Fratzl, Richard Weinkamer, Nature's hierarchical materials, <i>Progress, in Materials Science</i> 52 (2007) 1263-1334 Journal publications		

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M0775: Ergonomics			
Courses			
Title	Typ	Hrs/wk	CP
Ergonomics (L0653)	Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective 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		

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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics			
Courses			
Title	Typ	Hrs/wk	CP
Intelligent Autonomous Agents and Cognitive Robotics (L0341)	Lecture	2	4
Intelligent Autonomous Agents and Cognitive Robotics (L0512)	Recitation Section (small)	2	2
Module Responsible	Rainer Marrone		
Admission Requirements	None		
Recommended Previous Knowledge	Vectors, matrices, Calculus		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.</p> <p><i>Skills</i> Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.</p>		
Personal Competence	<p><i>Social Competence</i> Students are able to discuss their solutions to problems with others. They communicate in English</p> <p><i>Autonomy</i> Students are able of checking their understanding of complex concepts by solving variants of concrete problems</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L0341: Intelligent Autonomous Agents and Cognitive Robotics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 information Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks • Simultaneous Localization and Mapping • Planning • Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium • Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, • Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem
Literature	<ol style="list-style-type: none"> 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 Autonomous Agents and Cognitive Robotics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0751: Vibration Theory				
Courses				
Title		Typ	Hrs/wk	CP
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to denote terms and concepts of Vibration Theory and develop them further.			
<i>Skills</i>	Students are able to denote methods of Vibration Theory and develop them further.			
Personal Competence				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach individually research tasks in Vibration Theory.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.

Module M0808: Finite Elements Methods				
Courses				
Title		Typ	Hrs/wk	CP
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.			
<i>Skills</i>	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
Personal Competence				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.			
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 scale	120 min			
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M0814: Technology Management				
Courses				
Title		Typ	Hrs/wk	CP
Technology Management (L0849)		Lecture	3	3
Technology Management Seminar (L0850)		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students will gain deep insights into:</p> <ul style="list-style-type: none"> • International R&D-Management • Technology Timing Strategies <ul style="list-style-type: none"> ◦ Technology Strategies and Lifecycle Management (I/II) ◦ Technology Intelligence and Planning • Technology Portfolio Management <ul style="list-style-type: none"> ◦ Technology Portfolio Methodology ◦ Technology Acquisition and Exploitation ◦ IP Management • Organizing Technology Development <ul style="list-style-type: none"> ◦ Technology Organization & Management ◦ Technology Funding & Controlling <p><i>Skills</i> The course aims to:</p> <ul style="list-style-type: none"> • Develop an understanding of the importance of Technology Management - on a national as well as international level • Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects) • Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy • Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation) • Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include: <ul style="list-style-type: none"> • Basic concepts, models and tools, relevant to the management of technology, R&D and innovation • Innovation as a process (steps, activities and results) <p>Personal Competence</p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> • Interact within a team • Raise awareness for global issues <p><i>Autonomy</i></p> <ul style="list-style-type: none"> • Gain access to knowledge sources • Discuss recent research debates in the context of Technology and Innovation Management • 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	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

Course L0849: Technology Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p> <p>This lecture is part of the Module Technology Management and can not separately choosen.</p>
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Management Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p>
Literature	see lecture Technology Management.

Module M0768: Microsystems Technology in Theory and Practice				
Courses				
Title		Typ	Hrs/wk	CP
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 Knowledge	Basics in physics, chemistry, mechanics and semiconductor technology			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of 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. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> to analyze the feasibility of microsystems, to develop process flows for the fabrication of microstructures and to apply them. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
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 and practical work	Studierenden führen in Kleingruppen ein Laborpraktikum durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebnisse ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0724: Microsystems Technology	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Introduction (historical view, scientific and economic relevance, scaling laws) • Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) • Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) • Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) • Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) • Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) • Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process) • Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) • Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) • MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) • Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	<p>M. Madou: Fundamentals of Microfabrication, CRC Press, 2002</p> <p>N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009</p> <p>T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010</p> <p>G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008</p>

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

Module M0846: Control Systems Theory and Design				
Courses				
Title	Typ	Hrs/wk	CP	
Control Systems Theory and Design (L0656)	Lecture	2	4	
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2	
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p style="margin-left: 20px;"><i>Knowledge</i></p> <ul style="list-style-type: none"> Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively They can explain the significance of a minimal realisation They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection They can extend all of the above to multi-input multi-output systems They can explain the z-transform and its relationship with the Laplace Transform They can explain state space models and transfer function models of discrete-time systems They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation They can explain how a state space model can be constructed from a discrete-time impulse response <p style="margin-left: 20px;"><i>Skills</i></p> <ul style="list-style-type: none"> Students can transform transfer function models into state space models and vice versa They can assess controllability and observability and construct minimal realisations They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate They can identify transfer function models and state space models of dynamic systems from experimental data They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) <p style="margin-left: 20px;">Personal Competence</p> <p style="margin-left: 40px;"><i>Social Competence</i></p> <p>Students can work in small groups on specific problems to arrive at joint solutions.</p> <p style="margin-left: 40px;"><i>Autonomy</i></p> <p>Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.</p> <p>They can assess their knowledge in weekly on-line tests and thereby control their learning progress.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> • 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 <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> • 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 <p>Digital Control</p> <ul style="list-style-type: none"> • 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 <p>System identification and model order reduction</p> <ul style="list-style-type: none"> • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction <p>Case study</p> <ul style="list-style-type: none"> • Modelling and multivariable control of a process evaporator using Matlab and Simulink <p>Software tools</p> <ul style="list-style-type: none"> • Matlab/Simulink
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Module M0867: Production Planning & Control and Digital Enterprise	
Courses	
Title	Typ Hrs/wk CP
The Digital Enterprise (L0932)	Lecture 2 2
Production Planning and Control (L0929)	Lecture 2 2
Production Planning and Control (L0930)	Recitation Section (small) 1 1
Exercise: The Digital Enterprise (L0933)	Recitation Section (small) 1 1
Module Responsible	Prof. Hermann Lödding
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Production and Quality Management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
<i>Knowledge</i>	Students can explain the contents of the module in detail and take a critical position to them.
<i>Skills</i>	Students are capable of choosing and applying models and methods from the module to industrial problems.
Personal Competence	
<i>Social Competence</i>	Students can develop joint solutions in mixed teams and present them to others.
<i>Autonomy</i>	-
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 Minuten
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

Course L0932: The Digital Enterprise	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>Content:</p> <ul style="list-style-type: none"> • 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	<p>Scheer, A.-W.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002</p> <p>Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag, Berlin 3. Auflage 2006</p> <p>Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004</p> <p>Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007</p> <p>Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006</p>

Course L0929: Production Planning and Control	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 style="list-style-type: none"> • Vorlesungsskript • Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 • Nyhuis, P.; Wiendahl, H.-P.: Logistische Kennlinien, Springer 2002

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

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

Module M0921: Electronic Circuits for Medical Applications			
Courses			
Title		Typ	Hrs/wk CP
Electronic Circuits for Medical Applications (L0696)		Lecture	2 3
Electronic Circuits for Medical Applications (L1056)		Recitation Section (small)	1 2
Electronic Circuits for Medical Applications (L1408)		Practical Course	1 1
Module Responsible	Prof. Matthias Kuhl		
Admission Requirements	None		
Recommended Previous Knowledge	Fundamentals of electrical engineering		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain the basic functionality of the information transfer by the central nervous system • Students are able to explain the build-up of an action potential and its propagation along an axon • Students can exemplify the communication between neurons and electronic devices • Students can describe the special features of low-noise amplifiers for medical applications • Students can explain the functions of prostheses, e. g. an artificial hand • Students are able to discuss the potential and limitations of cochlea implants and artificial eyes 		
<i>Skills</i>	<ul style="list-style-type: none"> • Students can calculate the time dependent voltage behavior of an action potential • Students can give scenarios for further improvement of low-noise and low-power signal acquisition. • Students can develop the block diagrams of prosthetic systems • Students can define the building blocks of electronic systems for an artificial eye. 		
Personal Competence			
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. • Students are able to recognize their specific limitations, so that they can ask for assistance to the right time. • Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary 		
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. • Students can break down their work in appropriate work packages and schedule their work in a realistic way. • Students can handle the complex data structures of bioelectrical experiments without needing support. • Students are able to act in a responsible manner in all cases and situations of experimental work. 		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	Compulsory	Bonus	Form Description
	Yes	None	Subject theoretical and practical work
	No	None	Exercises
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0696: Electronic Circuits for Medical Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvo03.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

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

Course L1408: Electronic Circuits for Medical Applications	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

Module M1150: Continuum Mechanics				
Courses				
Title		Typ	Hrs/wk	CP
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
<i>Skills</i>	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence				
<i>Social Competence</i>	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
<i>Autonomy</i>	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L1533: Continuum Mechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Fundamentals of tensor calculus <ul style="list-style-type: none"> ◦ Transformation invariance ◦ Tensor algebra ◦ Tensor analysis • Kinematics <ul style="list-style-type: none"> ◦ Motion of continuum ◦ Deformation of infinitesimal line, area and volume elements ◦ Material and spatial description ◦ Polar decomposition ◦ Spectral decomposition ◦ Objectivity ◦ Strain measures ◦ Time derivatives <ul style="list-style-type: none"> ▪ Partial / material time derivatives ▪ Objective time rates ▪ Strain and deformation rates ◦ Transport theorems • Balance equations (global and local form) <ul style="list-style-type: none"> ◦ Balance of mass ◦ The stress state <ul style="list-style-type: none"> ▪ Surface traction vectors ▪ Cauchy's fundamental theorem ▪ Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor) ◦ Balance of linear momentum ◦ Balance of angular momentum ◦ Balance of energy ◦ Balance of entropy ◦ Clausius-Duhem inequality • Constitutive laws <ul style="list-style-type: none"> ◦ Constitutive assumptions ◦ Fluids ◦ Elastic solids <ul style="list-style-type: none"> ▪ Hyperelasticity ▪ Material symmetry ◦ Elasto-plastic solids • Analysis <ul style="list-style-type: none"> ◦ Initial-boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer weitere siehe in der Literaturliste des Scripts

Course L1534: Continuum Mechanics Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • kinematics of undeformed and deformed bodies • balance equations (balance of mass, balance of energy, ...) • stress states • material modelling
Literature	<p>R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker</p> <p>I-S. Liu: Continuum Mechanics, Springer</p>

Module M1151: Materials Modeling				
Courses				
Title		Typ	Hrs/wk	CP
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> The students can explain the fundamentals of multidimensional constitutive material laws</p> <p><i>Skills</i> The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.</p>			
Personal Competence	<p><i>Social Competence</i> The students are able to develop solutions, to present them to specialists and to develop ideas further.</p> <p><i>Autonomy</i> The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L1535: Material Modeling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<p>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</p> <ul style="list-style-type: none"> - 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) <p>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.</p>
Literature	

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

Module M1199: Advanced Functional Materials			
Courses			
Title	Typ	Hrs/wk	CP
Advanced Functional Materials (L1625)	Seminar	2	6
Module Responsible	Prof. Patrick Huber		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.</p>		
Personal Competence	<p><i>Social Competence</i> The students are able to present solutions to specialists and to develop ideas further.</p> <p><i>Autonomy</i> The students are able to ...</p> <ul style="list-style-type: none"> • 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	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory		

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

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

Courses			
Title	Typ	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Approval of Medical Devices (L1588)	Lecture	2	3
Experimental Methods in Biomechanics (L0377)	Lecture	2	3
Experimental Methods for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1890)	Seminar	2	3
Fluid Mechanics II (L0001)	Lecture	2	4
System Simulation (L1820)	Lecture	2	2
System Simulation (L1821)	Recitation Section (large)	1	2
Ceramics Technology (L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Depends on choice of courses		
Credit points	12		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory		

Course L1663: Nature's Hierarchical Materials

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwiager K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M1279: MED II: Introduction to Biochemistry and Molecular Biology			
Courses			
Title	Introduction to Biochemistry and Molecular Biology (L0386)	Typ	Lecture
		Hrs/wk	2
		CP	3
Module Responsible	Prof. Hans-Jürgen Kreienkamp		
Admission Requirements	None		
Recommended Previous Knowledge	None		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 		
<i>Skills</i>	The students can <ul style="list-style-type: none"> recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 		
Personal Competence			
<i>Social Competence</i>	The students can participate in discussions in research and medicine on a technical level.		
<i>Autonomy</i>	The students can develop understanding of topics from the course, using technical literature, by themselves.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

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

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

Course L0593: Biomaterials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (Importance, nomenclature, relations) 2. Biological materials <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <p>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.</p>
Literature	<p>Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.</p> <p>Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.</p> <p>Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.</p> <p>Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.</p> <p>Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.</p> <p>Wintermantel, E. und Ha, S.-W : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.</p>

Module M1342: Polymers				
Courses				
Title		Typ	Hrs/wk	CP
Structure and Properties of Polymers (L0389)		Lecture	2	3
Processing and design with polymers (L1892)		Lecture	2	3
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				
<i>Knowledge</i>	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).			
<i>Skills</i>	Students are capable of - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.			
Personal Competence				
<i>Social Competence</i>	Students can - arrive at funded work results in heterogenous groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively.			
<i>Autonomy</i>	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Structure and Properties of Polymers	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> - Structure and properties of polymers - Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weight distribution - Morphology amorph, crystalline, blends - Properties Elasticity, plasticity, viscoelasticity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

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

Module M0632: Regenerative Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Regenerative Medicine (L0347)		Seminar	2	3
Lecture Tissue Engineering - Regenerative Medicine (L1664)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.			
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic underlying principles of the discussed topics.			
<i>Skills</i>	After successful completion of the module students are			
	<ul style="list-style-type: none"> • able to use medical databases for acquiring and presentation of relevant up-to-date data independently • able to present their work results in the form of presentations • able to carry out basic cell culture methods and the corresponding analysis independently • able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 			
Personal Competence				
<i>Social Competence</i>	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			
	Students are able to reflect their work orally and discuss it with other students and teachers.			
<i>Autonomy</i>	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persons independently including a presentation of the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / protocol for lecture series
Examination	Presentation			
Examination duration and scale	Oral presentation + discussion (30 min)			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

Course L0347: Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
Content	<p>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:</p> <ul style="list-style-type: none"> • Introduction (historical development, examples for medical and technical applications, commercial aspects) • 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 <p>The fundamentals will be presented by the lecturers.</p> <p>The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.</p>
Literature	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Course L1664: Lecture Tissue Engineering - Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	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	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Module M1333: BIO I: Implants and Fracture Healing				
Courses				
Title	Typ	Hrs/wk	CP	
Implants and Fracture Healing (L0376)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			
Personal Competence				
<i>Social Competence</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
<i>Autonomy</i>	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 scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (history, definitions, background importance) 2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius) 3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 5.1 Basics and biology of fracture repair 5.2 Clinical principals and terminology of fracture treatment 5.3 Biomechanics of fracture treatment <ol style="list-style-type: none"> 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	<p>Cochran V.B.: Orthopädische Biomechanik</p> <p>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics</p> <p>White A.A., Panjabi M.M.: Clinical biomechanics of the spine</p> <p>Nigg, B.: Biomechanics of the musculo-skeletal system</p> <p>Schiebler T.H., Schmidt W.: Anatomie</p> <p>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat</p>

Module M0630: Robotics and Navigation in Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Robotics and Navigation in Medicine (L0335)		Lecture	2	3
Robotics and Navigation in Medicine (L0338)		Project Seminar	2	2
Robotics and Navigation in Medicine (L0336)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of programming, e.g., in Java or C++ • solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.			
<i>Skills</i>	The students are able to design and evaluate navigation systems and robotic systems for medical applications.			
Personal Competence				
<i>Social Competence</i>	The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Written elaboration	
	Yes	10 %	Presentation	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0335: Robotics and Navigation in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> - kinematics - calibration - tracking systems - navigation and image guidance - motion compensation <p>The seminar extends and complements the contents of the lecture with respect to recent research results.</p>
Literature	<p>Spong et al.: Robot Modeling and Control, 2005</p> <p>Troccaz: Medical Robotics, 2012</p> <p>Further literature will be given in the lecture.</p>

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

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

Module M1384: Case Studies for Regenerative Medicine and Tissue Engineering			
Courses			
Title		Typ	Hrs/wk CP
Case Studies for Regenerative Medicine and Tissue Engineering (L1963)		Seminar	3 6
Module Responsible	Prof. Ralf Pörtner		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42		
Credit points	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	45 min		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory 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	
Typ	Seminar
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	

Module M0634: Introduction into Medical Technology and Systems				
Courses				
Title		Typ	Hrs/wk	CP
Introduction into Medical Technology and Systems (L0342)		Lecture	2	3
Introduction into Medical Technology and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technology and Systems (L1876)		Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.			
<i>Skills</i>	The students are able to evaluate systems and medical devices in the context of clinical applications.			
Personal Competence				
<i>Social Competence</i>	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Presentation	
	Yes	10 %	Written elaboration	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

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

Course L1876: Introduction into Medical Technology and Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> - imaging systems - computer aided surgery - medical sensor systems - medical information systems - regulatory affairs - standard in medical technology <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonlinear Dynamics				
Courses				
Title		Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
<i>Skills</i>	Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.			
Personal Competence				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

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

Module M0761: Semiconductor Technology				
Courses				
Title	Typ	Hrs/wk	CP	
Semiconductor Technology (L0722)	Lecture	4	4	
Semiconductor Technology (L0723)	Practical Course	2	2	
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semiconductor devices			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> 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 semiconductor devices. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0722: Semiconductor Technology	
Typ	Lecture
Hrs/wk	4
CP	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 style="list-style-type: none"> • Introduction (historical view and trends in microelectronics) • Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) • Wafer fabrication (process flow, specification, SOI) • Fabrication processes • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) • Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) • Process integration (CMOS process, bipolar process) • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact: wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	<p>S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons</p> <p>S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons</p> <p>U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag</p> <p>H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag</p> <p>K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin</p> <p>S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press</p> <p>P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill</p>

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

Module M0835: Humanoid Robotics				
Courses				
Title	Typ	Hrs/wk	CP	
Humanoid Robotics (L0663)	Seminar	2	2	
Module Responsible	Patrick Götttsch			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Introduction to control systems • Control theory and design 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain humanoid robots. • Students learn to apply basic control concepts for different tasks in humanoid robotics. 			
<i>Knowledge</i>				
<i>Skills</i>	<ul style="list-style-type: none"> • Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature • Students generalize developed results and present them to the participants • Students practice to prepare and give a presentation 			
Personal Competence	<ul style="list-style-type: none"> • Students are capable of developing solutions in interdisciplinary teams and present them • They are able to provide appropriate feedback and handle constructive criticism of their own results 			
<i>Social Competence</i>				
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution • Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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 Robotics and Computer Science: Elective Compulsory			

Course L0663: Humanoid Robotics	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Patrick Götttsch
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Grundlagen der Regelungstechnik • Control systems theory and design
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).

Module M0838: Linear and Nonlinear System Identification				
Courses				
Title		Typ	Hrs/wk	CP
Linear and Nonlinear System Identification (L0660)		Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Discrete-time systems • Linear algebra, singular value decomposition • Basic knowledge about stochastic processes 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures • They can explain how multilayer perceptron networks are used to model nonlinear dynamics • They can explain how an approximate predictive control scheme can be based on neural network models • They can explain the idea of subspace identification and its relation to Kalman realisation theory 			
<i>Knowledge</i>				
<i>Skills</i>	<ul style="list-style-type: none"> • Students are capable of applying the prediction 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 applying subspace algorithms to the experimental identification of linear models for dynamic systems • They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
Personal Competence	<p><i>Social Competence</i> Students can work in mixed groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0660: Linear and Nonlinear System Identification	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Prediction error method • Linear and nonlinear model structures • Nonlinear model structure based on multilayer perceptron network • Approximate predictive control based on multilayer perceptron network model • Subspace identification
Literature	<ul style="list-style-type: none"> • Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 • M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003 • T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000

Module M0840: Optimal and Robust Control				
Courses				
Title		Typ	Hrs/wk	CP
Optimal and Robust Control (L0658)		Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> • 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 constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant. • They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities. <p><i>Skills</i></p> <ul style="list-style-type: none"> • Students are capable of designing and tuning LQG controllers for multivariable plant models. • They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it. • They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design. • They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. • They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them. • They can carry out all of the above using standard software tools (Matlab robust control toolbox). <p>Personal Competence</p> <p><i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0658: Optimal and Robust Control	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H₂ and H_∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H_∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H₂, H_∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

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

Module M0855: Marketing (Sales and Services / Innovation Marketing)			
Courses			
Title	Typ	Hrs/wk	CP
Marketing of Innovations (L2009)	Lecture	4	4
PBL Marketing of Innovations (L0862)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian L�uthje		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Module International Business • 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) • Understanding the differences between 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	<p><i>Knowledge</i> Students will have gained a deep understanding of</p> <ul style="list-style-type: none"> • Specific characteristics in the marketing of innovative products and services • Approaches for analyzing the current market situation and the future market development • The gathering of information about future customer needs and requirements • Concepts and approaches to integrate lead users and their needs into product and service development processes • Approaches and tools for ensuring customer-orientation in the development of new products and innovative 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 <p><i>Skills</i> Based on the acquired knowledge students will be able to:</p> <ul style="list-style-type: none"> • 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 • Make strategic sales decisions for products and services (i.e. selection of sales channels) • Apply methods of sales force management (i.e. customer value analysis) 		
Personal Competence	<p><i>Social Competence</i> The students will be able to</p> <ul style="list-style-type: none"> • 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 <p><i>Autonomy</i> The students will be able to</p> <ul style="list-style-type: none"> • 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	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	Written elaboration, exercises, presentation, oral participation		
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

Course L2009: Marketing of Innovations	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>I. Introduction</p> <ul style="list-style-type: none"> • Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing) <p>II. Methods and approaches of strategic marketing planning</p> <ul style="list-style-type: none"> • patterns of industrial development, patent and technology portfolios <p>III. Strategic foresight and scenario analysis</p> <ul style="list-style-type: none"> • objectives and challenges of strategic foresight, scenario analysis, Delphi method <p>IV. User innovations</p> <ul style="list-style-type: none"> • Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis <p>V. Customer-oriented Product and Service Engineering</p> <ul style="list-style-type: none"> • Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting <p>VII. Pricing</p> <ul style="list-style-type: none"> • Basics of Pricing, Value-based pricing, Pricing models <p>VIII. Sales Management</p> <ul style="list-style-type: none"> • Basics of Sales Management, Assessing Customer Value, Planning Customer Visits <p>IX. Communications</p> <ul style="list-style-type: none"> • Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	<p>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).</p> <p>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGraw Hill, Boston et al., 2008</p> <p>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.</p> <p>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill</p> <p>Tidd, J. & Hull, Frank M. (Editors) (2007) Service Innovation, London</p> <p>Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press</p>

Course L0862: PBL Marketing of Innovations	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>This PBL course is segregated into two afternoon sessions. This course 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.</p>
Literature	

Module M1143: Applied Design Methodology in Mechatronics				
Courses				
Title		Typ	Hrs/wk	CP
Applied Design Methodology in Mechatronics (L1523)		Lecture	2	2
Applied Design Methodology in Mechatronics (L1524)		Project-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques			
<i>Skills</i>	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.			
Personal Competence				
<i>Social Competence</i>	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.			
<i>Autonomy</i>	Students are enabled to optimize the design and development process according to the target and topic of the design			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and scale	30 min Presentation for a group design-work			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L1523: Applied Design Methodology in Mechatronics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Systematic analysis and planning of the design process for products combining a multitude of disciplines • Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) • Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, ... - Applications in examples all around mechatronics topics) • Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continuous integration and testing, ...) • Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparison), dealing with uncertainties, decision-making • Value-analysis • Derivation of architectures and architectural management • Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) • Project-execution methods (Scrum, Kanbaan, ...) • Presentation-skills • Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) • Evaluation of selected methods at practical examples in small teams
Literature	<ul style="list-style-type: none"> • Definition folgt... • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 • VDI-Richtlinien: 2206; 2221ff

Course L1524: Applied Design Methodology in Mechatronics	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	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 M0938: Bioprocess Engineering - Fundamentals				
Courses				
Title		Typ	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamentals (L0842)		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental Practical Course (L0843)		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", module "fundamentals for process engineering"			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
<i>Skills</i>	After successful completion of this module, students should be able to <ul style="list-style-type: none"> describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 			
Personal Competence				
<i>Social Competence</i>	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.			
<i>Autonomy</i>	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	5 %	Subject	theoretical and practical work
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory			

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, different types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of substrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuous bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p>

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	<p>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.</p> <p>The students document their experiments and results in a protocol.</p>
Literature	Skript

Module M1280: MED 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 Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 			
<i>Skills</i>	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development of forces and vital functions) and relate them to similar technical systems.			
Personal Competence				
<i>Social Competence</i>	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.			
<i>Autonomy</i>	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 scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			
Course L0385: Introduction to Physiology				
Typ	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Dr. Gerhard Engler			
Language	DE			
Cycle	SoSe			
Content				
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier			

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

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

Module M1278: MED I: Introduction to Radiology and Radiation Therapy				
Courses				
Title	Typ	Hrs/wk	CP	
Introduction to Radiology and Radiation Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<p>Therapy</p> <p>The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.</p> <p>The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).</p> <p>The students can describe the patients' passage from their initial admittance through to follow-up care.</p> <p>Diagnostics</p> <p>The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).</p> <p>The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.</p> <p>The students can choose the right treatment method depending on the patient's clinical history and needs.</p> <p>The student can explain the influence of technical errors on the imaging techniques.</p> <p>The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.</p>			
<i>Skills</i>	<p>Therapy</p> <p>The students can distinguish curative and palliative situations and motivate why they came to that conclusion.</p> <p>The students can develop adequate therapy concepts and relate it to the radiation biological aspects.</p> <p>The students can use the therapeutic principle (effects vs adverse effects)</p> <p>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).</p> <p>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).</p> <p>Diagnostics</p> <p>The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.</p> <p>The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.</p>			
Personal Competence				
<i>Social Competence</i>	<p>The students can assess the special social situation of tumor patients and interact with them in a professional way.</p> <p>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.</p>			
<i>Autonomy</i>	<p>The students can apply their new knowledge and skills to a concrete therapy case.</p> <p>The students can introduce younger students to the clinical daily routine.</p> <p>The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory			

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

Course L0383: Introduction to Radiology and Radiation Therapy	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments
Literature	<ul style="list-style-type: none"> • "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	Typ	Hrs/wk	CP
Artificial Joint Replacement (L1306)	Lecture	2	3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can name the different kinds of artificial limbs.		
<i>Skills</i>	The students can explain the advantages and disadvantages of different kinds of endoprotheses.		
Personal Competence			
<i>Social Competence</i>	The students are able to discuss issues related to endoprothese with student mates and the teachers.		
<i>Autonomy</i>	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	<p>Inhalt (deutsch)</p> <ol style="list-style-type: none"> 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenkersatzes) 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, Gelenkersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz) 8. DIE HAND (Anatomie, Biomechanik, Gelenkersatz) 9. TRIBOLOGIE NATÜRLICHER UND KÜNSTLICHER GELENKE (Korrosion, Reibung, Verschleiß)
Literature	<p>Literatur:</p> <p>Kapandji, I.: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.</p> <p>Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994</p> <p>Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.</p> <p>Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.</p> <p>Sobotta und Netter für Anatomie der Gelenke</p>

Module M0845: Feedback Control in Medical Technology			
Courses			
Title		Typ	Hrs/wk
Feedback Control in Medical Technology (L0664)		Lecture	2
			CP
			3
Module Responsible	Johannes Kreuzer		
Admission Requirements	None		
Recommended Previous Knowledge	Basics in Control, Basics in Physiology		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory. Internal control loops of the human body will be discussed in the same way like the design of external closed loop system for example in for anesthesia control. The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.		
<i>Skills</i>	Application of modeling, identification, control technology in the field of medical technology.		
Personal Competence			
<i>Social Competence</i>	Students can develop solutions to specific problems in small groups and present their results		
<i>Autonomy</i>	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 scale	20 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective 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: Compulsory		

Course L0664: Feedback Control in Medical Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

Module M0832: Advanced 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 Knowledge	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> • Students can explain the advantages and shortcomings of the classical gain scheduling approach • They can explain the representation of nonlinear systems in the form of quasi-LPV systems • They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions • They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems • They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures <p><i>Skills</i></p> <ul style="list-style-type: none"> • Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems • They can explain the convergence properties of first order consensus protocols • They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models • Students can explain concepts behind linear and qLPV Model Predictive Control (MPC) • Students can construct LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models • They can use standard software tools (Matlab robust control toolbox) for these tasks • Students can design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided • Students can design MPC controllers for linear and non-linear systems using Matlab tools <p>Personal Competence</p> <p><i>Social Competence</i> Students can work in small groups and arrive at joint results.</p> <p><i>Autonomy</i> Students can find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Linear Parameter-Varying (LPV) Gain Scheduling <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> • 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0548: Bioelectromagnetics: Principles and Applications				
Courses				
Title		Typ	Hrs/wk	CP
Bioelectromagnetics: Principles and Applications (L0371)		Lecture	3	5
Bioelectromagnetics: Principles and Applications (L0373)		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Basic principles of physics			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.			
<i>Skills</i>	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence				
<i>Social Competence</i>	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).			
<i>Autonomy</i>	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 Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Presentation	
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0371: Bioelectromagnetics: Principles and Applications	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Artificial Organs and Regenerative Medicine

Module M0623: Intelligent Systems in Medicine

Courses

Title	Typ	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)	Lecture	2	3
Intelligent Systems in Medicine (L0334)	Project Seminar	2	2
Intelligent Systems in Medicine (L0333)	Recitation Section (small)	1	1

Module Responsible	Prof. Alexander Schlaefer												
Admission Requirements	None												
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of stochastics • principles of programming, Java/C++ and R/Matlab • advanced programming skills 												
Educational Objectives	After taking part successfully, students have reached the following learning results												
Professional Competence													
<i>Knowledge</i>	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.												
<i>Skills</i>	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.												
Personal Competence													
<i>Social Competence</i>	The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.												
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.												
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70												
Credit points	6												
Course achievement	<table border="1"> <thead> <tr> <th>Compulsory</th> <th>Bonus</th> <th>Form</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>Yes</td> <td>10 %</td> <td>Written elaboration</td> <td></td> </tr> <tr> <td>Yes</td> <td>10 %</td> <td>Presentation</td> <td></td> </tr> </tbody> </table>	Compulsory	Bonus	Form	Description	Yes	10 %	Written elaboration		Yes	10 %	Presentation	
Compulsory	Bonus	Form	Description										
Yes	10 %	Written elaboration											
Yes	10 %	Presentation											
Examination	Written exam												
Examination duration and scale	90 minutes												
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory 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 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 Bio- and Medical Technology: Elective Compulsory												

Course L0331: Intelligent Systems in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - methods for search, optimization, planning, classification, regression and prediction in a clinical context - representation of medical knowledge - understanding challenges due to clinical and patient related data and data acquisition The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Russel & Norvig: Artificial Intelligence: a Modern Approach, 2012 Berner: Clinical Decision Support Systems: Theory and Practice, 2007 Greenes: Clinical Decision Support: The Road Ahead, 2007 Further literature will be given in the lecture

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

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

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)	
Courses	
Title	Typ Hrs/wk CP
Nature's Hierarchical Materials (L1663)	Seminar 2 3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture 3 4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small) 2 2
Development and Regulatory Approval of Medical Devices (L1588)	Lecture 2 3
Experimental Methods in Biomechanics (L0377)	Lecture 2 3
Experimental Methods for the Characterization of Materials (L1580)	Lecture 2 3
Numerical Methods in Biomechanics (L1583)	Seminar 2 3
Seminar Biomedical Engineering (L1890)	Seminar 2 3
Fluid Mechanics II (L0001)	Lecture 2 4
System Simulation (L1820)	Lecture 2 2
System Simulation (L1821)	Recitation Section (large) 1 2
Ceramics Technology (L0379)	Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence <i>Knowledge</i> <i>Skills</i> Personal Competence <i>Social Competence</i> <i>Autonomy</i>	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M0775: Ergonomics			
Courses			
Title		Typ	Hrs/wk
Ergonomics (L0653)		Lecture	2
			CP
			3
Module Responsible	Dr. Armin Bossemeyer		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>			
<i>Skills</i>			
Personal Competence			
<i>Social Competence</i>			
<i>Autonomy</i>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective 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		

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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics			
Courses			
Title		Typ	Hrs/wk CP
Intelligent Autonomous Agents and Cognitive Robotics (L0341)		Lecture	2 4
Intelligent Autonomous Agents and Cognitive Robotics (L0512)		Recitation Section (small)	2 2
Module Responsible	Rainer Marrone		
Admission Requirements	None		
Recommended Previous Knowledge	Vectors, matrices, Calculus		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.		
<i>Skills</i>	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.		
Personal Competence			
<i>Social Competence</i>	Students are able to discuss their solutions to problems with others. They communicate in English		
<i>Autonomy</i>	Students are able of checking their understanding of complex concepts by solving variants of concrete problems		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L0341: Intelligent Autonomous Agents and Cognitive Robotics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 information Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks • Simultaneous Localization and Mapping • Planning • Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium • Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, • Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem
Literature	<ol style="list-style-type: none"> 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 Autonomous Agents and Cognitive Robotics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0751: Vibration Theory				
Courses				
Title		Typ	Hrs/wk	CP
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students are able to denote terms and concepts of Vibration Theory and develop them further.</p> <p><i>Skills</i> Students are able to denote methods of Vibration Theory and develop them further.</p>			
Personal Competence	<p><i>Social Competence</i> Students can reach working results also in groups.</p> <p><i>Autonomy</i> Students are able to approach individually research tasks in Vibration Theory.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: 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	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.

Module M0814: Technology Management				
Courses				
Title		Typ	Hrs/wk	CP
Technology Management (L0849)		Lecture	3	3
Technology Management Seminar (L0850)		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students will gain deep insights into:</p> <ul style="list-style-type: none"> • International R&D-Management • Technology Timing Strategies <ul style="list-style-type: none"> ◦ Technology Strategies and Lifecycle Management (I/II) ◦ Technology Intelligence and Planning • Technology Portfolio Management <ul style="list-style-type: none"> ◦ Technology Portfolio Methodology ◦ Technology Acquisition and Exploitation ◦ IP Management • Organizing Technology Development <ul style="list-style-type: none"> ◦ Technology Organization & Management ◦ Technology Funding & Controlling <p><i>Skills</i> The course aims to:</p> <ul style="list-style-type: none"> • Develop an understanding of the importance of Technology Management - on a national as well as international level • Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects) • Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy • Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation) • Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include: <ul style="list-style-type: none"> • Basic concepts, models and tools, relevant to the management of technology, R&D and innovation • Innovation as a process (steps, activities and results) <p>Personal Competence</p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> • Interact within a team • Raise awareness for global issues <p><i>Autonomy</i></p> <ul style="list-style-type: none"> • Gain access to knowledge sources • Discuss recent research debates in the context of Technology and Innovation Management • 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	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

Course L0849: Technology Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p> <p>This lecture is part of the Module Technology Management and can not separately choosen.</p>
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inooation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Management Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p>
Literature	see lecture Technology Management.

Module M0846: Control Systems Theory and Design				
Courses				
Title	Typ	Hrs/wk	CP	
Control Systems Theory and Design (L0656)	Lecture	2	4	
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2	
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence	<ul style="list-style-type: none"> • Students can transform transfer function models into state space models and vice versa • They can assess controllability and observability and construct minimal realisations • They can design LQG controllers for multivariable plants • They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate • They can identify transfer function models and state space models of dynamic systems from experimental data • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) 			
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. 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 in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> • 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 <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> • 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 <p>Digital Control</p> <ul style="list-style-type: none"> • 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 <p>System identification and model order reduction</p> <ul style="list-style-type: none"> • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction <p>Case study</p> <ul style="list-style-type: none"> • Modelling and multivariable control of a process evaporator using Matlab and Simulink <p>Software tools</p> <ul style="list-style-type: none"> • Matlab/Simulink
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Module M0867: Production Planning & Control and Digital Enterprise				
Courses				
Title		Typ	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929)		Lecture	2	2
Production Planning and Control (L0930)		Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Quality Management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can explain the contents of the module in detail and take a critical position to them.			
<i>Skills</i>	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
<i>Social Competence</i>	Students can develop joint solutions in mixed teams and present them to others.			
<i>Autonomy</i>	-			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L0932: The Digital Enterprise	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>Content:</p> <ul style="list-style-type: none"> • 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	<p>Scheer, A.-W.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002</p> <p>Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag, Berlin 3. Auflage 2006</p> <p>Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004</p> <p>Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007</p> <p>Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006</p>

Course L0929: Production Planning and Control	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 style="list-style-type: none"> • Vorlesungsskript • Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 • Nyhuis, P.; Wiendahl, H.-P.: Logistische Kennlinien, Springer 2002

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

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

Module M0921: Electronic Circuits for Medical Applications				
Courses				
Title		Typ	Hrs/wk	CP
Electronic Circuits for Medical Applications (L0696)		Lecture	2	3
Electronic Circuits for Medical Applications (L1056)		Recitation Section (small)	1	2
Electronic Circuits for Medical Applications (L1408)		Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain the basic functionality of the information transfer by the central nervous system • Students are able to explain the build-up of an action potential and its propagation along an axon • Students can exemplify the communication between neurons and electronic devices • Students can describe the special features of low-noise amplifiers for medical applications • Students can explain the functions of prostheses, e. g. an artificial hand • Students are able to discuss the potential and limitations of cochlea implants and artificial eyes 			
<i>Skills</i>	<ul style="list-style-type: none"> • Students can calculate the time dependent voltage behavior of an action potential • Students can give scenarios for further improvement of low-noise and low-power signal acquisition. • Students can develop the block diagrams of prosthetic systems • Students can define the building blocks of electronic systems for an artificial eye. 			
Personal Competence				
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. • Students are able to recognize their specific limitations, so that they can ask for assistance to the right time. • Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary 			
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. • Students can break down their work in appropriate work packages and schedule their work in a realistic way. • Students can handle the complex data structures of bioelectrical experiments without needing support. • Students are able to act in a responsible manner in all cases and situations of experimental work. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Subject	theoretical and practical work
	No	None	Exercises	
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0696: Electronic Circuits for Medical Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvo03.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

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

Course L1408: Electronic Circuits for Medical Applications	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

Module M1150: Continuum Mechanics				
Courses				
Title		Typ	Hrs/wk	CP
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
<i>Skills</i>	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence				
<i>Social Competence</i>	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
<i>Autonomy</i>	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L1533: Continuum Mechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Fundamentals of tensor calculus <ul style="list-style-type: none"> ◦ Transformation invariance ◦ Tensor algebra ◦ Tensor analysis • Kinematics <ul style="list-style-type: none"> ◦ Motion of continuum ◦ Deformation of infinitesimal line, area and volume elements ◦ Material and spatial description ◦ Polar decomposition ◦ Spectral decomposition ◦ Objectivity ◦ Strain measures ◦ Time derivatives <ul style="list-style-type: none"> ▪ Partial / material time derivatives ▪ Objective time rates ▪ Strain and deformation rates ◦ Transport theorems • Balance equations (global and local form) <ul style="list-style-type: none"> ◦ Balance of mass ◦ The stress state <ul style="list-style-type: none"> ▪ Surface traction vectors ▪ Cauchy's fundamental theorem ▪ Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor) ◦ Balance of linear momentum ◦ Balance of angular momentum ◦ Balance of energy ◦ Balance of entropy ◦ Clausius-Duhem inequality • Constitutive laws <ul style="list-style-type: none"> ◦ Constitutive assumptions ◦ Fluids ◦ Elastic solids <ul style="list-style-type: none"> ▪ Hyperelasticity ▪ Material symmetry ◦ Elasto-plastic solids • Analysis <ul style="list-style-type: none"> ◦ Initial-boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer weitere siehe in der Literaturliste des Scripts

Course L1534: Continuum Mechanics Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • kinematics of undeformed and deformed bodies • balance equations (balance of mass, balance of energy, ...) • stress states • material modelling
Literature	<p>R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker</p> <p>I-S. Liu: Continuum Mechanics, Springer</p>

Module M1151: Materials Modeling				
Courses				
Title		Typ	Hrs/wk	CP
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	The students can explain the fundamentals of multidimensional constitutive material laws The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models. The students are able to develop solutions, to present them to specialists and to develop ideas further. The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence				
<i>Social Competence</i>				
<i>Autonomy</i>				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L1535: Material Modeling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<p>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</p> <ul style="list-style-type: none"> - 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) <p>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.</p>
Literature	

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

Module M1199: Advanced Functional Materials			
Courses			
Title		Typ	Hrs/wk CP
Advanced Functional Materials (L1625)		Seminar	2 6
Module Responsible	Prof. Patrick Huber		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	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.		
<i>Skills</i>	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.		
Personal Competence			
<i>Social Competence</i>	The students are able to present solutions to specialists and to develop ideas further.		
<i>Autonomy</i>	The students are able to ...		
	<ul style="list-style-type: none"> • 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	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory		

Course L1625: Advanced Functional Materials	
Typ	Seminar
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Fritz Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
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.

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M1279: MED II: Introduction to Biochemistry and Molecular Biology				
Courses				
Title	Introduction to Biochemistry and Molecular Biology (L0386)	Typ	Lecture	Hrs/wk 2 CP 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 			
<i>Skills</i>	The students can <ul style="list-style-type: none"> recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 			
Personal Competence				
<i>Social Competence</i>	The students can participate in discussions in research and medicine on a technical level.			
<i>Autonomy</i>	The students can develop understanding of topics from the course, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			
Course L0386: Introduction to Biochemistry and Molecular Biology				
Typ	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Hans-Jürgen Kreienkamp			
Language	DE			
Cycle	WiSe			
Content				
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008			

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

Course L0593: Biomaterials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (Importance, nomenclature, relations) 2. Biological materials <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <p>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.</p>
Literature	<p>Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.</p> <p>Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.</p> <p>Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.</p> <p>Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.</p> <p>Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.</p> <p>Wintermantel, E. und Ha, S.-W : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.</p>

Module M0808: Finite Elements Methods				
Courses				
Title		Typ	Hrs/wk	CP
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.			
<i>Skills</i>	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
Personal Competence				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.			
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 scale	120 min			
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M1342: Polymers				
Courses				
Title		Typ	Hrs/wk	CP
Structure and Properties of Polymers (L0389)		Lecture	2	3
Processing and design with polymers (L1892)		Lecture	2	3
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				
<i>Knowledge</i>	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).			
<i>Skills</i>	Students are capable of - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.			
Personal Competence				
<i>Social Competence</i>	Students can - arrive at funded work results in heterogenous groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively.			
<i>Autonomy</i>	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Structure and Properties of Polymers	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> - Structure and properties of polymers - Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weight distribution - Morphology amorph, crystalline, blends - Properties Elasticity, plasticity, viscoelasticity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

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

Module M0632: Regenerative Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Regenerative Medicine (L0347)		Seminar	2	3
Lecture Tissue Engineering - Regenerative Medicine (L1664)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.			
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic underlying principles of the discussed topics.			
<i>Skills</i>	After successful completion of the module students are			
	<ul style="list-style-type: none"> • able to use medical databases for acquiring and presentation of relevant up-to-date data independently • able to present their work results in the form of presentations • able to carry out basic cell culture methods and the corresponding analysis independently • able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 			
Personal Competence				
<i>Social Competence</i>	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			
	Students are able to reflect their work orally and discuss it with other students and teachers.			
<i>Autonomy</i>	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persons independently including a presentation of the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / protocol for lecture series
Examination	Presentation			
Examination duration and scale	Oral presentation + discussion (30 min)			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

Course L0347: Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
Content	<p>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:</p> <ul style="list-style-type: none"> • Introduction (historical development, examples for medical and technical applications, commercial aspects) • 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 <p>The fundamentals will be presented by the lecturers.</p> <p>The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.</p>
Literature	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Course L1664: Lecture Tissue Engineering - Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	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	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Module M1333: BIO I: Implants and Fracture Healing				
Courses				
Title	Typ	Hrs/wk	CP	
Implants and Fracture Healing (L0376)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			
Personal Competence				
<i>Social Competence</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
<i>Autonomy</i>	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 scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (history, definitions, background importance) 2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius) 3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 5.1 Basics and biology of fracture repair 5.2 Clinical principals and terminology of fracture treatment 5.3 Biomechanics of fracture treatment <ol style="list-style-type: none"> 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	<p>Cochran V.B.: Orthopädische Biomechanik</p> <p>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics</p> <p>White A.A., Panjabi M.M.: Clinical biomechanics of the spine</p> <p>Nigg, B.: Biomechanics of the musculo-skeletal system</p> <p>Schiebler T.H., Schmidt W.: Anatomie</p> <p>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat</p>

Module M0768: Microsystems Technology in Theory and Practice				
Courses				
Title		Typ	Hrs/wk	CP
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 Knowledge	Basics in physics, chemistry, mechanics and semiconductor technology			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of 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. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> to analyze the feasibility of microsystems, to develop process flows for the fabrication of microstructures and to apply them. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
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 and practical work	Studierenden führen in Kleingruppen ein Laborpraktikum durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebnisse ihrer Labortätigkeit vor dem gesamten Kurs.
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0724: Microsystems Technology	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Introduction (historical view, scientific and economic relevance, scaling laws) • Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) • Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) • Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) • Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) • Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) • Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process) • Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) • Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) • MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) • Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	<p>M. Madou: Fundamentals of Microfabrication, CRC Press, 2002</p> <p>N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009</p> <p>T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010</p> <p>G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008</p>

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

Module M0630: Robotics and Navigation in Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Robotics and Navigation in Medicine (L0335)		Lecture	2	3
Robotics and Navigation in Medicine (L0338)		Project Seminar	2	2
Robotics and Navigation in Medicine (L0336)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of programming, e.g., in Java or C++ • solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.			
<i>Skills</i>	The students are able to design and evaluate navigation systems and robotic systems for medical applications.			
Personal Competence				
<i>Social Competence</i>	The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Written elaboration	
	Yes	10 %	Presentation	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0335: Robotics and Navigation in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> - kinematics - calibration - tracking systems - navigation and image guidance - motion compensation <p>The seminar extends and complements the contents of the lecture with respect to recent research results.</p>
Literature	<p>Spong et al.: Robot Modeling and Control, 2005</p> <p>Troccaz: Medical Robotics, 2012</p> <p>Further literature will be given in the lecture.</p>

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

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

Module M1384: Case Studies for Regenerative Medicine and Tissue Engineering			
Courses			
Title		Typ	Hrs/wk CP
Case Studies for Regenerative Medicine and Tissue Engineering (L1963)		Seminar	3 6
Module Responsible	Prof. Ralf Pörtner		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42		
Credit points	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	45 min		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory 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	
Typ	Seminar
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	

Module M0634: Introduction into Medical Technology and Systems				
Courses				
Title		Typ	Hrs/wk	CP
Introduction into Medical Technology and Systems (L0342)		Lecture	2	3
Introduction into Medical Technology and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technology and Systems (L1876)		Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.			
<i>Skills</i>	The students are able to evaluate systems and medical devices in the context of clinical applications.			
Personal Competence				
<i>Social Competence</i>	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Presentation	
	Yes	10 %	Written elaboration	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

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

Course L1876: Introduction into Medical Technology and Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> - imaging systems - computer aided surgery - medical sensor systems - medical information systems - regulatory affairs - standard in medical technology <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonlinear Dynamics				
Courses				
Title		Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
<i>Skills</i>	Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.			
Personal Competence				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

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

Module M0761: Semiconductor Technology				
Courses				
Title	Typ	Hrs/wk	CP	
Semiconductor Technology (L0722)	Lecture	4	4	
Semiconductor Technology (L0723)	Practical Course	2	2	
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semiconductor devices			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> 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 semiconductor devices. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0722: Semiconductor Technology	
Typ	Lecture
Hrs/wk	4
CP	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 style="list-style-type: none"> • Introduction (historical view and trends in microelectronics) • Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) • Wafer fabrication (process flow, specification, SOI) • Fabrication processes • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) • Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) • Process integration (CMOS process, bipolar process) • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact: wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	<p>S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons</p> <p>S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons</p> <p>U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag</p> <p>H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag</p> <p>K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin</p> <p>S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press</p> <p>P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill</p>

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

Module M0835: Humanoid Robotics					
Courses					
Title	Typ	Hrs/wk	CP		
Humanoid Robotics (L0663)	Seminar	2	2		
Module Responsible	Patrick Götttsch				
Admission Requirements	None				
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Introduction to control systems • Control theory and design 				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence	<ul style="list-style-type: none"> • Students can explain humanoid robots. • Students learn to apply basic control concepts for different tasks in humanoid robotics. 				
<i>Knowledge</i>					
<i>Skills</i>					<ul style="list-style-type: none"> • Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature • Students generalize developed results and present them to the participants • Students practice to prepare and give a presentation
Personal Competence					
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are capable of developing solutions in interdisciplinary teams and present them • They are able to provide appropriate feedback and handle constructive criticism of their own results 				
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution • Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Credit points	2				
Course achievement	None				
Examination	Presentation				
Examination duration and scale	30 min				
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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 Robotics and Computer Science: Elective Compulsory				

Course L0663: Humanoid Robotics	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Patrick Götttsch
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Grundlagen der Regelungstechnik • Control systems theory and design
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).

Module M0838: Linear and Nonlinear System Identification				
Courses				
Title		Typ	Hrs/wk	CP
Linear and Nonlinear System Identification (L0660)		Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Discrete-time systems • Linear algebra, singular value decomposition • Basic knowledge about stochastic processes 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures • They can explain how multilayer perceptron networks are used to model nonlinear dynamics • They can explain how an approximate predictive control scheme can be based on neural network models • They can explain the idea of subspace identification and its relation to Kalman realisation theory 			
<i>Knowledge</i>				
<i>Skills</i>	<ul style="list-style-type: none"> • Students are capable of applying the prediction 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 applying subspace algorithms to the experimental identification of linear models for dynamic systems • They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
Personal Competence	<p><i>Social Competence</i> Students can work in mixed groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0660: Linear and Nonlinear System Identification	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Prediction error method • Linear and nonlinear model structures • Nonlinear model structure based on multilayer perceptron network • Approximate predictive control based on multilayer perceptron network model • Subspace identification
Literature	<ul style="list-style-type: none"> • Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 • M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003 • T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000

Module M0840: Optimal and Robust Control				
Courses				
Title		Typ	Hrs/wk	CP
Optimal and Robust Control (L0658)		Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • 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 constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant. • They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities. 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence	<ul style="list-style-type: none"> • Students are capable of designing and tuning LQG controllers for multivariable plant models. • They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it. • They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design. • They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. • They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them. • They can carry out all of the above using standard software tools (Matlab robust control toolbox). 			
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0658: Optimal and Robust Control	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H₂ and H_∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H_∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H₂, H_∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

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

Module M0855: Marketing (Sales and Services / Innovation Marketing)			
Courses			
Title	Typ	Hrs/wk	CP
Marketing of Innovations (L2009)	Lecture	4	4
PBL Marketing of Innovations (L0862)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian L�uthje		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Module International Business • 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) • Understanding the differences between 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	<p><i>Knowledge</i> Students will have gained a deep understanding of</p> <ul style="list-style-type: none"> • Specific characteristics in the marketing of innovative products and services • Approaches for analyzing the current market situation and the future market development • The gathering of information about future customer needs and requirements • Concepts and approaches to integrate lead users and their needs into product and service development processes • Approaches and tools for ensuring customer-orientation in the development of new products and innovative 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 <p><i>Skills</i> Based on the acquired knowledge students will be able to:</p> <ul style="list-style-type: none"> • 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 • Make strategic sales decisions for products and services (i.e. selection of sales channels) • Apply methods of sales force management (i.e. customer value analysis) 		
Personal Competence	<p><i>Social Competence</i> The students will be able to</p> <ul style="list-style-type: none"> • 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 <p><i>Autonomy</i> The students will be able to</p> <ul style="list-style-type: none"> • 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	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	Written elaboration, exercises, presentation, oral participation		
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

Course L2009: Marketing of Innovations	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>I. Introduction</p> <ul style="list-style-type: none"> Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing) <p>II. Methods and approaches of strategic marketing planning</p> <ul style="list-style-type: none"> patterns of industrial development, patent and technology portfolios <p>III. Strategic foresight and scenario analysis</p> <ul style="list-style-type: none"> objectives and challenges of strategic foresight, scenario analysis, Delphi method <p>IV. User innovations</p> <ul style="list-style-type: none"> Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis <p>V. Customer-oriented Product and Service Engineering</p> <ul style="list-style-type: none"> Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting <p>VII. Pricing</p> <ul style="list-style-type: none"> Basics of Pricing, Value-based pricing, Pricing models <p>VIII. Sales Management</p> <ul style="list-style-type: none"> Basics of Sales Management, Assessing Customer Value, Planning Customer Visits <p>IX. Communications</p> <ul style="list-style-type: none"> Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	<p>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).</p> <p>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGraw Hill, Boston et al., 2008</p> <p>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.</p> <p>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill</p> <p>Tidd, J. & Hull, Frank M. (Editors) (2007) Service Innovation, London</p> <p>Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press</p>

Course L0862: PBL Marketing of Innovations	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>This PBL course is segregated into two afternoon sessions. This course 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.</p>
Literature	

Module M1143: Applied Design Methodology in Mechatronics			
Courses			
Title		Typ	Hrs/wk CP
Applied Design Methodology in Mechatronics (L1523)		Lecture	2 2
Applied Design Methodology in Mechatronics (L1524)		Project-/problem-based Learning	3 4
Module Responsible	Prof. Thorsten Kern		
Admission Requirements	None		
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques		
<i>Skills</i>	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.		
Personal Competence			
<i>Social Competence</i>	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.		
<i>Autonomy</i>	Students are enabled to optimize the design and development process according to the target and topic of the design		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	30 min Presentation for a group design-work		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory		

Course L1523: Applied Design Methodology in Mechatronics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Systematic analysis and planning of the design process for products combining a multitude of disciplines • Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) • Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, ... - Applications in examples all around mechatronics topics) • Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing, ...) • Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparison), dealing with uncertainties, decision-making • Value-analysis • Derivation of architectures and architectural management • Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) • Project-execution methods (Scrum, Kanbaan, ...) • Presentation-skills • Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) • Evaluation of selected methods at practical examples in small teams
Literature	<ul style="list-style-type: none"> • Definition folgt... • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 • VDI-Richtlinien: 2206; 2221ff

Course L1524: Applied Design Methodology in Mechatronics	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	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 M0938: Bioprocess Engineering - Fundamentals				
Courses				
Title		Typ	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamentals (L0842)		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental Practical Course (L0843)		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", module "fundamentals for process engineering"			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
<i>Skills</i>	After successful completion of this module, students should be able to <ul style="list-style-type: none"> describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 			
Personal Competence				
<i>Social Competence</i>	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.			
<i>Autonomy</i>	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	5 %	Subject	theoretical and practical work
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory			

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, different types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of substrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuous bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, centrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p>

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	<p>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.</p> <p>The students document their experiments and results in a protocol.</p>
Literature	Skript

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

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

Module M1280: MED 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 Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 			
<i>Skills</i>	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development of forces and vital functions) and relate them to similar technical systems.			
Personal Competence				
<i>Social Competence</i>	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.			
<i>Autonomy</i>	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 scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			
Course L0385: Introduction to Physiology				
Typ	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Dr. Gerhard Engler			
Language	DE			
Cycle	SoSe			
Content				
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier			

Module M1278: MED I: Introduction to Radiology and Radiation Therapy				
Courses				
Title	Typ	Hrs/wk	CP	
Introduction to Radiology and Radiation Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i></p> <p>Therapy</p> <p>The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.</p> <p>The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).</p> <p>The students can describe the patients' passage from their initial admittance through to follow-up care.</p> <p>Diagnostics</p> <p>The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).</p> <p>The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.</p> <p>The students can choose the right treatment method depending on the patient's clinical history and needs.</p> <p>The student can explain the influence of technical errors on the imaging techniques.</p> <p>The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.</p> <p><i>Skills</i></p> <p>Therapy</p> <p>The students can distinguish curative and palliative situations and motivate why they came to that conclusion.</p> <p>The students can develop adequate therapy concepts and relate it to the radiation biological aspects.</p> <p>The students can use the therapeutic principle (effects vs adverse effects)</p> <p>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).</p> <p>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).</p> <p>Diagnostics</p> <p>The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.</p> <p>The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>The students can assess the special social situation of tumor patients and interact with them in a professional way.</p> <p>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.</p> <p><i>Autonomy</i></p> <p>The students can apply their new knowledge and skills to a concrete therapy case.</p> <p>The students can introduce younger students to the clinical daily routine.</p> <p>The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory			

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

Course L0383: Introduction to Radiology and Radiation Therapy	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments
Literature	<ul style="list-style-type: none"> • "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		Typ	Hrs/wk CP
Artificial Joint Replacement (L1306)		Lecture	2 3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can name the different kinds of artificial limbs.		
<i>Skills</i>	The students can explain the advantages and disadvantages of different kinds of endoprotheses.		
Personal Competence			
<i>Social Competence</i>	The students are able to discuss issues related to endoprothese with student mates and the teachers.		
<i>Autonomy</i>	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	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: Feedback Control in Medical Technology				
Courses				
Title		Typ	Hrs/wk	CP
Feedback Control in Medical Technology (L0664)		Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Control, Basics in Physiology			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory. Internal control loops of the human body will be discussed in the same way like the design of external closed loop system for example in for anesthesia control. The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.			
<i>Skills</i>	Application of modeling, identification, control technology in the field of medical technology.			
Personal Competence				
<i>Social Competence</i>	Students can develop solutions to specific problems in small groups and present their results			
<i>Autonomy</i>	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 scale	20 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective 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: Compulsory			

Course L0664: Feedback Control in Medical Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

Module M0832: Advanced 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 Knowledge	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> • Students can explain the advantages and shortcomings of the classical gain scheduling approach • They can explain the representation of nonlinear systems in the form of quasi-LPV systems • They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions • They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems • They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures <p><i>Skills</i></p> <ul style="list-style-type: none"> • Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems • They can explain the convergence properties of first order consensus protocols • They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models • Students can explain concepts behind linear and qLPV Model Predictive Control (MPC) • Students can construct LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models • They can use standard software tools (Matlab robust control toolbox) for these tasks • Students can design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided • Students can design MPC controllers for linear and non-linear systems using Matlab tools <p><i>Personal Competence</i></p> <p><i>Social Competence</i> Students can work in small groups and arrive at joint results.</p> <p><i>Autonomy</i> Students can find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Linear Parameter-Varying (LPV) Gain Scheduling <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> • 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0548: Bioelectromagnetics: Principles and Applications				
Courses				
Title	Typ	Hrs/wk	CP	
Bioelectromagnetics: Principles and Applications (L0371)	Lecture	3	5	
Bioelectromagnetics: Principles and Applications (L0373)	Recitation Section (small)	2	1	
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Basic principles of physics			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications . They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.</p> <p><i>Skills</i> Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.</p> <p>Personal Competence</p> <p><i>Social Competence</i> Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).</p> <p><i>Autonomy</i> 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.</p>			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Presentation	
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0371: Bioelectromagnetics: Principles and Applications	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Management and Business Administration

Module M0623: Intelligent Systems in Medicine

Courses

Title	Typ	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)	Lecture	2	3
Intelligent Systems in Medicine (L0334)	Project Seminar	2	2
Intelligent Systems in Medicine (L0333)	Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of stochastics • principles of programming, Java/C++ and R/Matlab • advanced programming skills 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.</p> <p><i>Skills</i> The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.</p> <p>Personal Competence</p> <p><i>Social Competence</i> The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.</p> <p><i>Autonomy</i> The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.</p>		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	Compulsory	Bonus	Form
	Yes	10 %	Written elaboration
	Yes	10 %	Presentation
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory 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 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 Bio- and Medical Technology: Elective Compulsory		

Course L0331: Intelligent Systems in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - methods for search, optimization, planning, classification, regression and prediction in a clinical context - representation of medical knowledge - understanding challenges due to clinical and patient related data and data acquisition <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	<p>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</p>

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

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

Module M1230: Selected Topics of Biomedical Engineering - Option A (6 LP)	
Courses	
Title	Typ Hrs/wk CP
Nature's Hierarchical Materials (L1663)	Seminar 2 3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture 3 4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small) 2 2
Development and Regulatory Approval of Medical Devices (L1588)	Lecture 2 3
Experimental Methods in Biomechanics (L0377)	Lecture 2 3
Experimental Methods for the Characterization of Materials (L1580)	Lecture 2 3
Numerical Methods in Biomechanics (L1583)	Seminar 2 3
Seminar Biomedical Engineering (L1890)	Seminar 2 3
Fluid Mechanics II (L0001)	Lecture 2 4
System Simulation (L1820)	Lecture 2 2
System Simulation (L1821)	Recitation Section (large) 1 2
Ceramics Technology (L0379)	Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence <i>Knowledge</i> <i>Skills</i> Personal Competence <i>Social Competence</i> <i>Autonomy</i>	
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M0775: Ergonomics			
Courses			
Title	Typ	Hrs/wk	CP
Ergonomics (L0653)	Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective 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		

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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics			
Courses			
Title		Typ	Hrs/wk CP
Intelligent Autonomous Agents and Cognitive Robotics (L0341)		Lecture	2 4
Intelligent Autonomous Agents and Cognitive Robotics (L0512)		Recitation Section (small)	2 2
Module Responsible	Rainer Marrone		
Admission Requirements	None		
Recommended Previous Knowledge	Vectors, matrices, Calculus		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.		
<i>Skills</i>	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.		
Personal Competence			
<i>Social Competence</i>	Students are able to discuss their solutions to problems with others. They communicate in English		
<i>Autonomy</i>	Students are able of checking their understanding of complex concepts by solving variants of concrete problems		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L0341: Intelligent Autonomous Agents and Cognitive Robotics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 information Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks • Simultaneous Localization and Mapping • Planning • Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium • Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, • Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem
Literature	<ol style="list-style-type: none"> 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 Autonomous Agents and Cognitive Robotics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0751: Vibration Theory			
Courses			
Title		Typ	Hrs/wk CP
Vibration Theory (L0701)		Integrated Lecture	4 6
Module Responsible	Prof. Norbert Hoffmann		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> Students are able to denote terms and concepts of Vibration Theory and develop them further.</p> <p><i>Skills</i> Students are able to denote methods of Vibration Theory and develop them further.</p>		
Personal Competence	<p><i>Social Competence</i> Students can reach working results also in groups.</p> <p><i>Autonomy</i> Students are able to approach individually research tasks in Vibration Theory.</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	2 Hours		
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: 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	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.

Module M0808: Finite Elements Methods				
Courses				
Title		Typ	Hrs/wk	CP
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.			
<i>Skills</i>	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
Personal Competence				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.			
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 scale	120 min			
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M0814: Technology Management				
Courses				
Title		Typ	Hrs/wk	CP
Technology Management (L0849)		Lecture	3	3
Technology Management Seminar (L0850)		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students will gain deep insights into:</p> <ul style="list-style-type: none"> • International R&D-Management • Technology Timing Strategies <ul style="list-style-type: none"> ◦ Technology Strategies and Lifecycle Management (I/II) ◦ Technology Intelligence and Planning • Technology Portfolio Management <ul style="list-style-type: none"> ◦ Technology Portfolio Methodology ◦ Technology Acquisition and Exploitation ◦ IP Management • Organizing Technology Development <ul style="list-style-type: none"> ◦ Technology Organization & Management ◦ Technology Funding & Controlling <p><i>Skills</i> The course aims to:</p> <ul style="list-style-type: none"> • Develop an understanding of the importance of Technology Management - on a national as well as international level • Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects) • Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy • Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation) • Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include: <ul style="list-style-type: none"> • Basic concepts, models and tools, relevant to the management of technology, R&D and innovation • Innovation as a process (steps, activities and results) <p>Personal Competence</p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> • Interact within a team • Raise awareness for global issues <p><i>Autonomy</i></p> <ul style="list-style-type: none"> • Gain access to knowledge sources • Discuss recent research debates in the context of Technology and Innovation Management • 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	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

Course L0849: Technology Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p> <p>This lecture is part of the Module Technology Management and can not separately choosen.</p>
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inooation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Management Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p>
Literature	see lecture Technology Management.

Module M0768: Microsystems Technology in Theory and Practice				
Courses				
Title		Typ	Hrs/wk	CP
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 Knowledge	Basics in physics, chemistry, mechanics and semiconductor technology			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of 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. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> to analyze the feasibility of microsystems, to develop process flows for the fabrication of microstructures and to apply them. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
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 and practical work	Studierenden führen in Kleingruppen ein Laborpraktikum durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebnisse ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0724: Microsystems Technology	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Introduction (historical view, scientific and economic relevance, scaling laws) • Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) • Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) • Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) • Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) • Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) • Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process) • Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) • Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) • MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) • Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	<p>M. Madou: Fundamentals of Microfabrication, CRC Press, 2002</p> <p>N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009</p> <p>T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010</p> <p>G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008</p>

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

Module M0846: Control Systems Theory and Design				
Courses				
Title	Typ	Hrs/wk	CP	
Control Systems Theory and Design (L0656)	Lecture	2	4	
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2	
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence	<p><i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.</p> <p>They can assess their knowledge in weekly on-line tests and thereby control their learning progress.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> • 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 <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> • 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 <p>Digital Control</p> <ul style="list-style-type: none"> • 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 <p>System identification and model order reduction</p> <ul style="list-style-type: none"> • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction <p>Case study</p> <ul style="list-style-type: none"> • Modelling and multivariable control of a process evaporator using Matlab and Simulink <p>Software tools</p> <ul style="list-style-type: none"> • Matlab/Simulink
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Module M0867: Production Planning & Control and Digital Enterprise				
Courses				
Title		Typ	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929)		Lecture	2	2
Production Planning and Control (L0930)		Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Quality Management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can explain the contents of the module in detail and take a critical position to them.			
<i>Skills</i>	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
<i>Social Competence</i>	Students can develop joint solutions in mixed teams and present them to others.			
<i>Autonomy</i>	-			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L0932: The Digital Enterprise	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>Content:</p> <ul style="list-style-type: none"> • 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, A.-W.: 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	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 style="list-style-type: none"> • Vorlesungsskript • Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 • Nyhuis, P.; Wiendahl, H.-P.: Logistische Kennlinien, Springer 2002

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

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

Module M0921: Electronic Circuits for Medical Applications				
Courses				
Title		Typ	Hrs/wk	CP
Electronic Circuits for Medical Applications (L0696)		Lecture	2	3
Electronic Circuits for Medical Applications (L1056)		Recitation Section (small)	1	2
Electronic Circuits for Medical Applications (L1408)		Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain the basic functionality of the information transfer by the central nervous system • Students are able to explain the build-up of an action potential and its propagation along an axon • Students can exemplify the communication between neurons and electronic devices • Students can describe the special features of low-noise amplifiers for medical applications • Students can explain the functions of prostheses, e. g. an artificial hand • Students are able to discuss the potential and limitations of cochlea implants and artificial eyes 			
<i>Skills</i>	<ul style="list-style-type: none"> • Students can calculate the time dependent voltage behavior of an action potential • Students can give scenarios for further improvement of low-noise and low-power signal acquisition. • Students can develop the block diagrams of prosthetic systems • Students can define the building blocks of electronic systems for an artificial eye. 			
Personal Competence				
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. • Students are able to recognize their specific limitations, so that they can ask for assistance to the right time. • Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary 			
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. • Students can break down their work in appropriate work packages and schedule their work in a realistic way. • Students can handle the complex data structures of bioelectrical experiments without needing support. • Students are able to act in a responsible manner in all cases and situations of experimental work. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Subject theoretical and practical work	
	No	None	Exercises	
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0696: Electronic Circuits for Medical Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvo03.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

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

Course L1408: Electronic Circuits for Medical Applications	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

Module M1150: Continuum Mechanics				
Courses				
Title	Typ	Hrs/wk	CP	
Continuum Mechanics (L1533)	Lecture	2	3	
Continuum Mechanics Exercise (L1534)	Recitation Section (small)	2	3	
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i></p> <p>The students can explain the fundamental concepts to calculate the mechanical behavior of materials.</p> <p><i>Skills</i></p> <p>The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.</p> <p>Personal Competence</p> <p><i>Social Competence</i></p> <p>The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.</p> <p><i>Autonomy</i></p> <p>The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.</p>			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L1533: Continuum Mechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Fundamentals of tensor calculus <ul style="list-style-type: none"> ◦ Transformation invariance ◦ Tensor algebra ◦ Tensor analysis • Kinematics <ul style="list-style-type: none"> ◦ Motion of continuum ◦ Deformation of infinitesimal line, area and volume elements ◦ Material and spatial description ◦ Polar decomposition ◦ Spectral decomposition ◦ Objectivity ◦ Strain measures ◦ Time derivatives <ul style="list-style-type: none"> ▪ Partial / material time derivatives ▪ Objective time rates ▪ Strain and deformation rates ◦ Transport theorems • Balance equations (global and local form) <ul style="list-style-type: none"> ◦ Balance of mass ◦ The stress state <ul style="list-style-type: none"> ▪ Surface traction vectors ▪ Cauchy's fundamental theorem ▪ Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor) ◦ Balance of linear momentum ◦ Balance of angular momentum ◦ Balance of energy ◦ Balance of entropy ◦ Clausius-Duhem inequality • Constitutive laws <ul style="list-style-type: none"> ◦ Constitutive assumptions ◦ Fluids ◦ Elastic solids <ul style="list-style-type: none"> ▪ Hyperelasticity ▪ Material symmetry ◦ Elasto-plastic solids • Analysis <ul style="list-style-type: none"> ◦ Initial-boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer weitere siehe in der Literaturliste des Scripts

Course L1534: Continuum Mechanics Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • kinematics of undeformed and deformed bodies • balance equations (balance of mass, balance of energy, ...) • stress states • material modelling
Literature	<p>R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker</p> <p>I-S. Liu: Continuum Mechanics, Springer</p>

Module M1151: Materials Modeling				
Courses				
Title		Typ	Hrs/wk	CP
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain the fundamentals of multidimensional constitutive material laws			
<i>Skills</i>	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
<i>Social Competence</i>	The students are able to develop solutions, to present them to specialists and to develop ideas further.			
<i>Autonomy</i>	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L1535: Material Modeling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<p>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</p> <ul style="list-style-type: none"> - 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) <p>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.</p>
Literature	

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

Module M1199: Advanced Functional Materials			
Courses			
Title		Typ	Hrs/wk CP
Advanced Functional Materials (L1625)		Seminar	2 6
Module Responsible	Prof. Patrick Huber		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	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.		
<i>Skills</i>	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.		
Personal Competence			
<i>Social Competence</i>	The students are able to present solutions to specialists and to develop ideas further.		
<i>Autonomy</i>	The students are able to ...		
	<ul style="list-style-type: none"> • 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	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory		

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

Module M1241: Selected Topics of Biomedical Engineering - Option B (12 LP)	
Courses	
Title	Typ Hrs/wk CP
Nature's Hierarchical Materials (L1663)	Seminar 2 3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture 3 4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small) 2 2
Development and Regulatory Approval of Medical Devices (L1588)	Lecture 2 3
Experimental Methods in Biomechanics (L0377)	Lecture 2 3
Experimental Methods for the Characterization of Materials (L1580)	Lecture 2 3
Numerical Methods in Biomechanics (L1583)	Seminar 2 3
Seminar Biomedical Engineering (L1890)	Seminar 2 3
Fluid Mechanics II (L0001)	Lecture 2 4
System Simulation (L1820)	Lecture 2 2
System Simulation (L1821)	Recitation Section (large) 1 2
Ceramics Technology (L0379)	Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence <i>Knowledge</i> <i>Skills</i> Personal Competence <i>Social Competence</i> <i>Autonomy</i>	
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 throu porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M1279: MED II: Introduction to Biochemistry and Molecular Biology			
Courses			
Title		Typ	Hrs/wk
Introduction to Biochemistry and Molecular Biology (L0386)		Lecture	2
CP			3
Module Responsible	Prof. Hans-Jürgen Kreienkamp		
Admission Requirements	None		
Recommended Previous Knowledge	None		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 		
<i>Skills</i>	The students can <ul style="list-style-type: none"> recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 		
Personal Competence			
<i>Social Competence</i>	The students can participate in discussions in research and medicine on a technical level.		
<i>Autonomy</i>	The students can develop understanding of topics from the course, using technical literature, by themselves.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

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

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

Course L0593: Biomaterials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (Importance, nomenclature, relations) 2. Biological materials <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <p>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.</p>
Literature	<p>Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.</p> <p>Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.</p> <p>Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.</p> <p>Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.</p> <p>Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.</p> <p>Wintermantel, E. und Ha, S.-W : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.</p>

Module M1342: Polymers				
Courses				
Title		Typ	Hrs/wk	CP
Structure and Properties of Polymers (L0389)		Lecture	2	3
Processing and design with polymers (L1892)		Lecture	2	3
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				
<i>Knowledge</i>	Students can use the knowledge of plastics and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).			
<i>Skills</i>	Students are capable of - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.			
Personal Competence				
<i>Social Competence</i>	Students can - arrive at funded work results in heterogenous groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively.			
<i>Autonomy</i>	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Structure and Properties of Polymers	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> - Structure and properties of polymers - Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weight distribution - Morphology amorph, crystalline, blends - Properties Elasticity, plasticity, viscoelasticity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

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

Module M0632: Regenerative Medicine				
Courses				
Title	Typ	Hrs/wk	CP	
Regenerative Medicine (L0347)	Seminar	2	3	
Lecture Tissue Engineering - Regenerative Medicine (L1664)	Seminar	2	3	
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.</p> <p>The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic underlying principles of the discussed topics.</p> <p><i>Skills</i> After successful completion of the module students are</p> <ul style="list-style-type: none"> • able to use medical databases for acquiring and presentation of relevant up-to-date data independently • able to present their work results in the form of presentations • able to carry out basic cell culture methods and the corresponding analysis independently • able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. <p>Personal Competence</p> <p><i>Social Competence</i> Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.</p> <p>Students are able to reflect their work orally and discuss it with other students and teachers.</p> <p><i>Autonomy</i></p> <p>After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persons independently including a presentation of the results.</p>			
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 / protocol for lecture series
Examination	Presentation			
Examination duration and scale	Oral presentation + discussion (30 min)			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

Course L0347: Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
Content	<p>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:</p> <ul style="list-style-type: none"> • Introduction (historical development, examples for medical and technical applications, commercial aspects) • 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 <p>The fundamentals will be presented by the lecturers.</p> <p>The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.</p>
Literature	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Course L1664: Lecture Tissue Engineering - Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	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	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Module M1333: BIO I: Implants and Fracture Healing				
Courses				
Title	Typ	Hrs/wk	CP	
Implants and Fracture Healing (L0376)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			
Personal Competence				
<i>Social Competence</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
<i>Autonomy</i>	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 scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (history, definitions, background importance) 2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius) 3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 5.1 Basics and biology of fracture repair 5.2 Clinical principals and terminology of fracture treatment 5.3 Biomechanics of fracture treatment <ol style="list-style-type: none"> 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	<p>Cochran V.B.: Orthopädische Biomechanik</p> <p>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics</p> <p>White A.A., Panjabi M.M.: Clinical biomechanics of the spine</p> <p>Nigg, B.: Biomechanics of the musculo-skeletal system</p> <p>Schiebler T.H., Schmidt W.: Anatomie</p> <p>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat</p>

Module M0630: Robotics and Navigation in Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Robotics and Navigation in Medicine (L0335)		Lecture	2	3
Robotics and Navigation in Medicine (L0338)		Project Seminar	2	2
Robotics and Navigation in Medicine (L0336)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of programming, e.g., in Java or C++ • solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.			
<i>Skills</i>	The students are able to design and evaluate navigation systems and robotic systems for medical applications.			
Personal Competence				
<i>Social Competence</i>	The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Written elaboration	
	Yes	10 %	Presentation	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0335: Robotics and Navigation in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> - kinematics - calibration - tracking systems - navigation and image guidance - motion compensation <p>The seminar extends and complements the contents of the lecture with respect to recent research results.</p>
Literature	<p>Spong et al.: Robot Modeling and Control, 2005</p> <p>Troccaz: Medical Robotics, 2012</p> <p>Further literature will be given in the lecture.</p>

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

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

Module M1384: Case Studies for Regenerative Medicine and Tissue Engineering				
Courses				
Title		Typ	Hrs/wk	CP
Case Studies for Regenerative Medicine and Tissue Engineering (L1963)		Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence <i>Knowledge</i> <i>Skills</i>				
Personal Competence <i>Social Competence</i> <i>Autonomy</i>				
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42			
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory 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	
Typ	Seminar
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	

Module M0634: Introduction into Medical Technology and Systems				
Courses				
Title		Typ	Hrs/wk	CP
Introduction into Medical Technology and Systems (L0342)		Lecture	2	3
Introduction into Medical Technology and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technology and Systems (L1876)		Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.			
<i>Skills</i>	The students are able to evaluate systems and medical devices in the context of clinical applications.			
Personal Competence				
<i>Social Competence</i>	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Presentation	
	Yes	10 %	Written elaboration	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

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

Course L1876: Introduction into Medical Technology and Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> - imaging systems - computer aided surgery - medical sensor systems - medical information systems - regulatory affairs - standard in medical technology <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonlinear Dynamics				
Courses				
Title		Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
<i>Skills</i>	Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.			
Personal Competence				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

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

Module M0761: Semiconductor Technology				
Courses				
Title		Typ	Hrs/wk	CP
Semiconductor Technology (L0722)		Lecture	4	4
Semiconductor Technology (L0723)		Practical Course	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semiconductor devices			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> 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 semiconductor devices. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0722: Semiconductor Technology	
Typ	Lecture
Hrs/wk	4
CP	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 style="list-style-type: none"> • Introduction (historical view and trends in microelectronics) • Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) • Wafer fabrication (process flow, specification, SOI) • Fabrication processes • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) • Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) • Process integration (CMOS process, bipolar process) • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact: wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	<p>S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons</p> <p>S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons</p> <p>U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag</p> <p>H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag</p> <p>K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin</p> <p>S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press</p> <p>P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill</p>

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

Module M0835: Humanoid Robotics					
Courses					
Title	Typ	Hrs/wk	CP		
Humanoid Robotics (L0663)	Seminar	2	2		
Module Responsible	Patrick Götttsch				
Admission Requirements	None				
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Introduction to control systems • Control theory and design 				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence	<ul style="list-style-type: none"> • Students can explain humanoid robots. • Students learn to apply basic control concepts for different tasks in humanoid robotics. 				
<i>Knowledge</i>					
<i>Skills</i>					<ul style="list-style-type: none"> • Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature • Students generalize developed results and present them to the participants • Students practice to prepare and give a presentation
Personal Competence					
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are capable of developing solutions in interdisciplinary teams and present them • They are able to provide appropriate feedback and handle constructive criticism of their own results 				
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution • Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Credit points	2				
Course achievement	None				
Examination	Presentation				
Examination duration and scale	30 min				
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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 Robotics and Computer Science: Elective Compulsory				

Course L0663: Humanoid Robotics	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Patrick Götttsch
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Grundlagen der Regelungstechnik • Control systems theory and design
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).

Module M0838: Linear and Nonlinear System Identification				
Courses				
Title		Typ	Hrs/wk	CP
Linear and Nonlinear System Identification (L0660)		Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Discrete-time systems • Linear algebra, singular value decomposition • Basic knowledge about stochastic processes 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures • They can explain how multilayer perceptron networks are used to model nonlinear dynamics • They can explain how an approximate predictive control scheme can be based on neural network models • They can explain the idea of subspace identification and its relation to Kalman realisation theory 			
<i>Knowledge</i>				
<i>Skills</i>	<ul style="list-style-type: none"> • Students are capable of applying the prediction 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 applying subspace algorithms to the experimental identification of linear models for dynamic systems • They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
Personal Competence	<p><i>Social Competence</i> Students can work in mixed groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0660: Linear and Nonlinear System Identification	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Prediction error method • Linear and nonlinear model structures • Nonlinear model structure based on multilayer perceptron network • Approximate predictive control based on multilayer perceptron network model • Subspace identification
Literature	<ul style="list-style-type: none"> • Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 • M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003 • T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000

Module M0840: Optimal and Robust Control				
Courses				
Title		Typ	Hrs/wk	CP
Optimal and Robust Control (L0658)		Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • 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 constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant. • They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities. 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence	<ul style="list-style-type: none"> • Students are capable of designing and tuning LQG controllers for multivariable plant models. • They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it. • They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design. • They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. • They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them. • They can carry out all of the above using standard software tools (Matlab robust control toolbox). 			
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0658: Optimal and Robust Control	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

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

Module M0855: Marketing (Sales and Services / Innovation Marketing)			
Courses			
Title		Typ	Hrs/wk CP
Marketing of Innovations (L2009)		Lecture	4 4
PBL Marketing of Innovations (L0862)		Project-/problem-based Learning	1 2
Module Responsible	Prof. Christian L�uthje		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Module International Business • 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) • Understanding the differences between 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	<p><i>Knowledge</i> Students will have gained a deep understanding of</p> <ul style="list-style-type: none"> • Specific characteristics in the marketing of innovative products and services • Approaches for analyzing the current market situation and the future market development • The gathering of information about future customer needs and requirements • Concepts and approaches to integrate lead users and their needs into product and service development processes • Approaches and tools for ensuring customer-orientation in the development of new products and innovative 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 <p><i>Skills</i> Based on the acquired knowledge students will be able to:</p> <ul style="list-style-type: none"> • 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 • Make strategic sales decisions for products and services (i.e. selection of sales channels) • Apply methods of sales force management (i.e. customer value analysis) 		
Personal Competence	<p><i>Social Competence</i> The students will be able to</p> <ul style="list-style-type: none"> • 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 <p><i>Autonomy</i> The students will be able to</p> <ul style="list-style-type: none"> • 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	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	Written elaboration, exercises, presentation, oral participation		
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

Course L2009: Marketing of Innovations	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>I. Introduction</p> <ul style="list-style-type: none"> • Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing) <p>II. Methods and approaches of strategic marketing planning</p> <ul style="list-style-type: none"> • patterns of industrial development, patent and technology portfolios <p>III. Strategic foresight and scenario analysis</p> <ul style="list-style-type: none"> • objectives and challenges of strategic foresight, scenario analysis, Delphi method <p>IV. User innovations</p> <ul style="list-style-type: none"> • Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis <p>V. Customer-oriented Product and Service Engineering</p> <ul style="list-style-type: none"> • Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting <p>VII. Pricing</p> <ul style="list-style-type: none"> • Basics of Pricing, Value-based pricing, Pricing models <p>VIII. Sales Management</p> <ul style="list-style-type: none"> • Basics of Sales Management, Assessing Customer Value, Planning Customer Visits <p>IX. Communications</p> <ul style="list-style-type: none"> • Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	<p>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).</p> <p>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGraw Hill, Boston et al., 2008</p> <p>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.</p> <p>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill</p> <p>Tidd, J. & Hull, Frank M. (Editors) (2007) Service Innovation, London</p> <p>Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press</p>

Course L0862: PBL Marketing of Innovations	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>This PBL course is segregated into two afternoon sessions. This course 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.</p>
Literature	

Module M1143: Applied Design Methodology in Mechatronics			
Courses			
Title		Typ	Hrs/wk CP
Applied Design Methodology in Mechatronics (L1523)		Lecture	2 2
Applied Design Methodology in Mechatronics (L1524)		Project-/problem-based Learning	3 4
Module Responsible	Prof. Thorsten Kern		
Admission Requirements	None		
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques		
<i>Skills</i>	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.		
Personal Competence			
<i>Social Competence</i>	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.		
<i>Autonomy</i>	Students are enabled to optimize the design and development process according to the target and topic of the design		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	30 min Presentation for a group design-work		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory		

Course L1523: Applied Design Methodology in Mechatronics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Systematic analysis and planning of the design process for products combining a multitude of disciplines • Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) • Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, ... - Applications in examples all around mechatronics topics) • Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continuous integration and testing, ...) • Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparison), dealing with uncertainties, decision-making • Value-analysis • Derivation of architectures and architectural management • Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) • Project-execution methods (Scrum, Kanbaan, ...) • Presentation-skills • Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) • Evaluation of selected methods at practical examples in small teams
Literature	<ul style="list-style-type: none"> • Definition folgt... • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 • VDI-Richtlinien: 2206; 2221ff

Course L1524: Applied Design Methodology in Mechatronics	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	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 M0938: Bioprocess Engineering - Fundamentals				
Courses				
Title		Typ	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamentals (L0842)		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental Practical Course (L0843)		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", module "fundamentals for process engineering"			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
<i>Skills</i>	After successful completion of this module, students should be able to <ul style="list-style-type: none"> describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 			
Personal Competence				
<i>Social Competence</i>	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.			
<i>Autonomy</i>	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	5 %	Subject	theoretical and practical work
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory			

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, different types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of substrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuous bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, centrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p>

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	<p>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.</p> <p>The students document their experiments and results in a protocol.</p>
Literature	Skript

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

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

Module M1280: MED 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 Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 			
<i>Skills</i>	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development of forces and vital functions) and relate them to similar technical systems.			
Personal Competence				
<i>Social Competence</i>	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.			
<i>Autonomy</i>	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 scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			
Course L0385: Introduction to Physiology				
Typ	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Dr. Gerhard Engler			
Language	DE			
Cycle	SoSe			
Content				
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier			

Module M1278: MED I: Introduction to Radiology and Radiation Therapy				
Courses				
Title	Typ	Hrs/wk	CP	
Introduction to Radiology and Radiation Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<p>Therapy</p> <p>The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.</p> <p>The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).</p> <p>The students can describe the patients' passage from their initial admittance through to follow-up care.</p> <p>Diagnostics</p> <p>The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).</p> <p>The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.</p> <p>The students can choose the right treatment method depending on the patient's clinical history and needs.</p> <p>The student can explain the influence of technical errors on the imaging techniques.</p> <p>The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.</p>			
<i>Skills</i>	<p>Therapy</p> <p>The students can distinguish curative and palliative situations and motivate why they came to that conclusion.</p> <p>The students can develop adequate therapy concepts and relate it to the radiation biological aspects.</p> <p>The students can use the therapeutic principle (effects vs adverse effects)</p> <p>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).</p> <p>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).</p> <p>Diagnostics</p> <p>The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.</p> <p>The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.</p>			
Personal Competence				
<i>Social Competence</i>	<p>The students can assess the special social situation of tumor patients and interact with them in a professional way.</p> <p>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.</p>			
<i>Autonomy</i>	<p>The students can apply their new knowledge and skills to a concrete therapy case.</p> <p>The students can introduce younger students to the clinical daily routine.</p> <p>The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p>			

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

Course L0383: Introduction to Radiology and Radiation Therapy	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments
Literature	<ul style="list-style-type: none"> • "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		Typ	Hrs/wk
Artificial Joint Replacement (L1306)		Lecture	2
			CP
			3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can name the different kinds of artificial limbs.		
<i>Skills</i>	The students can explain the advantages and disadvantages of different kinds of endoprotheses.		
Personal Competence			
<i>Social Competence</i>	The students are able to discuss issues related to endoprothese with student mates and the teachers.		
<i>Autonomy</i>	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	Inhalt (deutsch) <ol style="list-style-type: none"> 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenkersatzes) 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, Gelenkersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz) 8. DIE HAND (Anatomie, Biomechanik, Gelenkersatz) 9. TRIBOLOGIE NATÜRLICHER UND KÜNSTLICHER 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: Feedback Control in Medical Technology			
Courses			
Title		Typ	Hrs/wk
Feedback Control in Medical Technology (L0664)		Lecture	2
			CP
			3
Module Responsible	Johannes Kreuzer		
Admission Requirements	None		
Recommended Previous Knowledge	Basics in Control, Basics in Physiology		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory. Internal control loops of the human body will be discussed in the same way like the design of external closed loop system for example in for anesthesia control. The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.		
<i>Skills</i>	Application of modeling, identification, control technology in the field of medical technology.		
Personal Competence			
<i>Social Competence</i>	Students can develop solutions to specific problems in small groups and present their results		
<i>Autonomy</i>	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 scale	20 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective 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: Compulsory		

Course L0664: Feedback Control in Medical Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	Always viewed from the engineer's point of view, the lecture is structured as follows: <ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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.

Module M0832: Advanced 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 Knowledge	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> • Students can explain the advantages and shortcomings of the classical gain scheduling approach • They can explain the representation of nonlinear systems in the form of quasi-LPV systems • They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions • They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems • They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures <p><i>Skills</i></p> <ul style="list-style-type: none"> • Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems • They can explain the convergence properties of first order consensus protocols • They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models • Students can explain concepts behind linear and qLPV Model Predictive Control (MPC) • Students can construct LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models • They can use standard software tools (Matlab robust control toolbox) for these tasks • Students can design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided • Students can design MPC controllers for linear and non-linear systems using Matlab tools <p>Personal Competence</p> <p><i>Social Competence</i> Students can work in small groups and arrive at joint results.</p> <p><i>Autonomy</i> Students can find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Linear Parameter-Varying (LPV) Gain Scheduling <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> • 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0548: Bioelectromagnetics: Principles and Applications				
Courses				
Title		Typ	Hrs/wk	CP
Bioelectromagnetics: Principles and Applications (L0371)		Lecture	3	5
Bioelectromagnetics: Principles and Applications (L0373)		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Basic principles of physics			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.			
<i>Skills</i>	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence				
<i>Social Competence</i>	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).			
<i>Autonomy</i>	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 Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Presentation	
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0371: Bioelectromagnetics: Principles and Applications	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Medical Technology and Control Theory

Module M0623: Intelligent Systems in Medicine

Courses

Title	Typ	Hrs/wk	CP
Intelligent Systems in Medicine (L0331)	Lecture	2	3
Intelligent Systems in Medicine (L0334)	Project Seminar	2	2
Intelligent Systems in Medicine (L0333)	Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of stochastics • principles of programming, Java/C++ and R/Matlab • advanced programming skills 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i> The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.</p> <p><i>Skills</i> The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.</p> <p>Personal Competence</p> <p><i>Social Competence</i> The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.</p> <p><i>Autonomy</i> The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.</p>		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	Compulsory	Bonus	Form
	Yes	10 %	Written elaboration
	Yes	10 %	Presentation
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory 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 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 Bio- and Medical Technology: Elective Compulsory		

Course L0331: Intelligent Systems in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - methods for search, optimization, planning, classification, regression and prediction in a clinical context - representation of medical knowledge - understanding challenges due to clinical and patient related data and data acquisition <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	<p>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</p>

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

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „ Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwiager K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M0775: Ergonomics			
Courses			
Title	Typ	Hrs/wk	CP
Ergonomics (L0653)	Lecture	2	3
Module Responsible	Dr. Armin Bossemeyer		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective 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		

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

Module M0629: Intelligent Autonomous Agents and Cognitive Robotics			
Courses			
Title		Typ	Hrs/wk CP
Intelligent Autonomous Agents and Cognitive Robotics (L0341)		Lecture	2 4
Intelligent Autonomous Agents and Cognitive Robotics (L0512)		Recitation Section (small)	2 2
Module Responsible	Rainer Marrone		
Admission Requirements	None		
Recommended Previous Knowledge	Vectors, matrices, Calculus		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.		
<i>Skills</i>	Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.		
Personal Competence			
<i>Social Competence</i>	Students are able to discuss their solutions to problems with others. They communicate in English		
<i>Autonomy</i>	Students are able of checking their understanding of complex concepts by solving variants of concrete problems		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 minutes		
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L0341: Intelligent Autonomous Agents and Cognitive Robotics	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 information Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks • Simultaneous Localization and Mapping • Planning • Game theory (Golden Balls: Split or Share) Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium • Social Choice Voting protocols, preferences, paradoxes, Arrow's Theorem, • Mechanism Design Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem
Literature	<ol style="list-style-type: none"> 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 Autonomous Agents and Cognitive Robotics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Rainer Marrone
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0751: Vibration Theory			
Courses			
Title		Typ	Hrs/wk
Vibration Theory (L0701)		Integrated Lecture	4
			CP
			6
Module Responsible	Prof. Norbert Hoffmann		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	Students are able to denote terms and concepts of Vibration Theory and develop them further.		
<i>Skills</i>	Students are able to denote methods of Vibration Theory and develop them further.		
Personal Competence			
<i>Social Competence</i>	Students can reach working results also in groups.		
<i>Autonomy</i>	Students are able to approach individually research tasks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	2 Hours		
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves.
Literature	K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013.

Module M0814: Technology Management				
Courses				
Title		Typ	Hrs/wk	CP
Technology Management (L0849)		Lecture	3	3
Technology Management Seminar (L0850)		Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<p><i>Knowledge</i> Students will gain deep insights into:</p> <ul style="list-style-type: none"> • International R&D-Management • Technology Timing Strategies <ul style="list-style-type: none"> ◦ Technology Strategies and Lifecycle Management (I/II) ◦ Technology Intelligence and Planning • Technology Portfolio Management <ul style="list-style-type: none"> ◦ Technology Portfolio Methodology ◦ Technology Acquisition and Exploitation ◦ IP Management • Organizing Technology Development <ul style="list-style-type: none"> ◦ Technology Organization & Management ◦ Technology Funding & Controlling <p><i>Skills</i> The course aims to:</p> <ul style="list-style-type: none"> • Develop an understanding of the importance of Technology Management - on a national as well as international level • Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects) • Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy • Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation) • Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include: <ul style="list-style-type: none"> • Basic concepts, models and tools, relevant to the management of technology, R&D and innovation • Innovation as a process (steps, activities and results) <p>Personal Competence</p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> • Interact within a team • Raise awareness for global issues <p><i>Autonomy</i></p> <ul style="list-style-type: none"> • Gain access to knowledge sources • Discuss recent research debates in the context of Technology and Innovation Management • 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	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory			

Course L0849: Technology Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p> <p>This lecture is part of the Module Technology Management and can not separately chosen.</p>
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Innovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Management Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	<p>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.</p>
Literature	see lecture Technology Management.

Module M0768: Microsystems Technology in Theory and Practice				
Courses				
Title		Typ	Hrs/wk	CP
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 Knowledge	Basics in physics, chemistry, mechanics and semiconductor technology			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of 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. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> to analyze the feasibility of microsystems, to develop process flows for the fabrication of microstructures and to apply them. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
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 and practical work	Studierenden führen in Kleingruppen ein Laborpraktikum durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebnisse ihrer Labortätigkeit. vor dem gesamten Kurs.
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0724: Microsystems Technology	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Introduction (historical view, scientific and economic relevance, scaling laws) • Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) • Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing) • Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching) • Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping) • Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) • Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process) • Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) • Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) • MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) • Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) • System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	<p>M. Madou: Fundamentals of Microfabrication, CRC Press, 2002</p> <p>N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009</p> <p>T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010</p> <p>G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008</p>

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

Module M0846: Control Systems Theory and Design				
Courses				
Title		Typ	Hrs/wk	CP
Control Systems Theory and Design (L0656)		Lecture	2	4
Control Systems Theory and Design (L0657)		Recitation Section (small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response 			
<i>Skills</i>	<ul style="list-style-type: none"> • Students can transform transfer function models into state space models and vice versa • They can assess controllability and observability and construct minimal realisations • They can design LQG controllers for multivariable plants • They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate • They can identify transfer function models and state space models of dynamic systems from experimental data • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) 			
Personal Competence				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. 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 in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 min			
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<p>State space methods (single-input single-output)</p> <ul style="list-style-type: none"> • 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 <p>Multi-input multi-output systems</p> <ul style="list-style-type: none"> • 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 <p>Digital Control</p> <ul style="list-style-type: none"> • 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 <p>System identification and model order reduction</p> <ul style="list-style-type: none"> • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction <p>Case study</p> <ul style="list-style-type: none"> • Modelling and multivariable control of a process evaporator using Matlab and Simulink <p>Software tools</p> <ul style="list-style-type: none"> • Matlab/Simulink
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Module M0867: Production Planning & Control and Digital Enterprise				
Courses				
Title		Typ	Hrs/wk	CP
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (L0929)		Lecture	2	2
Production Planning and Control (L0930)		Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933)		Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Quality Management			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<i>Knowledge</i> Students can explain the contents of the module in detail and take a critical position to them. <i>Skills</i> Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence	<i>Social Competence</i> Students can develop joint solutions in mixed teams and present them to others. <i>Autonomy</i> -			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 Minuten			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 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 Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L0932: The Digital Enterprise	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Axel Friedewald
Language	DE
Cycle	WiSe
Content	<p>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.</p> <p>Content:</p> <ul style="list-style-type: none"> • 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, A.-W.: 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	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hermann Lödding
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 style="list-style-type: none"> • Vorlesungsskript • Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008 • Nyhuis, P.; Wiendahl, H.-P.: Logistische Kennlinien, Springer 2002

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

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

Module M0921: Electronic Circuits for Medical Applications				
Courses				
Title		Typ	Hrs/wk	CP
Electronic Circuits for Medical Applications (L0696)		Lecture	2	3
Electronic Circuits for Medical Applications (L1056)		Recitation Section (small)	1	2
Electronic Circuits for Medical Applications (L1408)		Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical engineering			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<ul style="list-style-type: none"> • Students can explain the basic functionality of the information transfer by the central nervous system • Students are able to explain the build-up of an action potential and its propagation along an axon • Students can exemplify the communication between neurons and electronic devices • Students can describe the special features of low-noise amplifiers for medical applications • Students can explain the functions of prostheses, e. g. an artificial hand • Students are able to discuss the potential and limitations of cochlea implants and artificial eyes 			
<i>Skills</i>	<ul style="list-style-type: none"> • Students can calculate the time dependent voltage behavior of an action potential • Students can give scenarios for further improvement of low-noise and low-power signal acquisition. • Students can develop the block diagrams of prosthetic systems • Students can define the building blocks of electronic systems for an artificial eye. 			
Personal Competence				
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are trained to solve problems in the field of medical electronics in teams together with experts with different professional background. • Students are able to recognize their specific limitations, so that they can ask for assistance to the right time. • Students can document their work in a clear manner and communicate their results in a way that others can be involved whenever it is necessary 			
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. • Students can break down their work in appropriate work packages and schedule their work in a realistic way. • Students can handle the complex data structures of bioelectrical experiments without needing support. • Students are able to act in a responsible manner in all cases and situations of experimental work. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Subject	theoretical and
	No	None	practical work	
			Exercises	
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0696: Electronic Circuits for Medical Applications	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvo03.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

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

Course L1408: Electronic Circuits for Medical Applications	
Typ	Practical Course
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Market for medical instruments • Membrane potential, action potential, sodium-potassium pump • Information transfer by the central nervous system • Interface tissue - electrode • Amplifiers for medical applications, analog-digital converters • Examples for electronic implants • Artificial eye, cochlea implant
Literature	<p>Kim E. Barret, Susan M. Barman, Scott Boitano and Heddwen L. Brooks</p> <p>Ganong's Review of Medical Physiology, 24nd Edition, McGraw Hill Lange, 2010</p> <p>Tier- und Humanphysiologie: Eine Einführung von Werner A. Müller (Author), Stephan Frings (Author), 657 p., 4. editions, Springer, 2009</p> <p>Robert F. Schmidt (Editor), Hans-Georg Schaible (Editor)</p> <p>Neuro- und Sinnesphysiologie (Springer-Lehrbuch) (Paper back), 488 p., Springer, 2006, 5. Edition, currently online only</p> <p>Russell K. Hobbie, Bradley J. Roth, Intermediate Physics for Medicine and Biology, Springer, 4th ed., 616 p., 2007</p> <p>Vorlesungen der Universität Heidelberg zur Tier- und Humanphysiologie: http://www.sinnesphysiologie.de/gruvo03/gruvoin.htm</p> <p>Internet: http://butler.cc.tut.fi/~malmivuo/bem/bembook/</p>

Module M1150: Continuum Mechanics				
Courses				
Title		Typ	Hrs/wk	CP
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1534)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
<i>Skills</i>	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence				
<i>Social Competence</i>	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
<i>Autonomy</i>	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L1533: Continuum Mechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Fundamentals of tensor calculus <ul style="list-style-type: none"> ◦ Transformation invariance ◦ Tensor algebra ◦ Tensor analysis • Kinematics <ul style="list-style-type: none"> ◦ Motion of continuum ◦ Deformation of infinitesimal line, area and volume elements ◦ Material and spatial description ◦ Polar decomposition ◦ Spectral decomposition ◦ Objectivity ◦ Strain measures ◦ Time derivatives <ul style="list-style-type: none"> ▪ Partial / material time derivatives ▪ Objective time rates ▪ Strain and deformation rates ◦ Transport theorems • Balance equations (global and local form) <ul style="list-style-type: none"> ◦ Balance of mass ◦ The stress state <ul style="list-style-type: none"> ▪ Surface traction vectors ▪ Cauchy's fundamental theorem ▪ Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor) ◦ Balance of linear momentum ◦ Balance of angular momentum ◦ Balance of energy ◦ Balance of entropy ◦ Clausius-Duhem inequality • Constitutive laws <ul style="list-style-type: none"> ◦ Constitutive assumptions ◦ Fluids ◦ Elastic solids <ul style="list-style-type: none"> ▪ Hyperelasticity ▪ Material symmetry ◦ Elasto-plastic solids • Analysis <ul style="list-style-type: none"> ◦ Initial-boundary value problems and their numerical solution
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer weitere siehe in der Literaturliste des Scripts

Course L1534: Continuum Mechanics Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • kinematics of undeformed and deformed bodies • balance equations (balance of mass, balance of energy, ...) • stress states • material modelling
Literature	<p>R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker</p> <p>I-S. Liu: Continuum Mechanics, Springer</p>

Module M1151: Materials Modeling				
Courses				
Title		Typ	Hrs/wk	CP
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	The students can explain the fundamentals of multidimensional constitutive material laws The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models. The students are able to develop solutions, to present them to specialists and to develop ideas further. The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence				
<i>Social Competence</i>				
<i>Autonomy</i>				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 min			
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L1535: Material Modeling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	<p>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</p> <ul style="list-style-type: none"> - 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) <p>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.</p>
Literature	

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

Module M1199: Advanced Functional Materials			
Courses			
Title		Typ	Hrs/wk CP
Advanced Functional Materials (L1625)		Seminar	2 6
Module Responsible	Prof. Patrick Huber		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	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.		
<i>Skills</i>	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.		
Personal Competence			
<i>Social Competence</i>	The students are able to present solutions to specialists and to develop ideas further.		
<i>Autonomy</i>	The students are able to ...		
	<ul style="list-style-type: none"> • 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	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory		

Course L1625: Advanced Functional Materials	
Typ	Seminar
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Stefan Fritz Müller, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Christian Cyron
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.

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1588: Development and Regulatory Approval of Medical Devices	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Roman Nassutt
Language	DE
Cycle	WiSe
Content	
Literature	<ul style="list-style-type: none"> • E. Wintermantel, S-W. Ha, Medizintechnik - Life Science Engineering, Springer Verlag, 5. Aufl. • Kurt Becker et al., Schriftenreihe der TMF, MVW Verlag, Berlin, 2001 • Medizinproduktegesetz in der aktuellen Fassung (online): http://www.gesetze-im-internet.de/mpg/BJNR196300994.html

Course L0377: Experimental Methods in Biomechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	Wird in der Veranstaltung bekannt gegeben

Course L1580: Experimental Methods for the Characterization of Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 min
Lecturer	Dr. Jürgen Markmann, Prof. Patrick Huber
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography) • Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements) • Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry)
Literature	<p>William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).</p> <p>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007).</p>

Course L1583: Numerical Methods in Biomechanics	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Vorkenntnisse aus „Diskretisierungsmethoden der Mechanik“ sind empfohlen • Ein Überblick über die gängigsten numerischen Verfahren im Bereich der Biomechanik und Medizintechnik wird vermittelt. • Grundkenntnissen aus verschiedenen Disziplinen (Mechanik, Mathematik, Programmierung...) werden kombiniert um eine geschlossene Beispielfragestellung zu beantworten • Die Vorlesung umfasst analytische Ansätze, rheologische Modelle und Finite Elemente Methoden • Die vermittelten theoretischen Ansätze werden im Laufe der Vorlesung und im Rahmen von Hausaufgaben in praktische Übungen angewandt. • Der kritische Blick auf die Möglichkeiten und Limitationen der Modellrechnung im Bereich humaner Anwendungen wird geschult.
Literature	Hauger W., Schnell W., Gross D., Technische Mechanik, Band 3: Kinetik, Springer-Verlag Berlin Heidelberg, 12. Auflage, 2012 Huber G., de Uhlenbrock A., Götzen N., Bishop N., Schwieger K., Morlock MM., Modellierung, Simulation und Optimierung, Handbuch Sportbiomechanik, Gollhofer A., Müller E., Hofmann Verlag, Schorndorf, 148-69, 2009

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

Course L0001: Fluid Mechanics II	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> • 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 through porous structures - heterogeneous catalysis • Pumps and turbines - Energy- and Environmental Process Engineering • Wind- and Wave-Turbines - Renewable Energy • Introduction into Computational Fluid Dynamics
Literature	<ol style="list-style-type: none"> 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. 2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994. 6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. 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 9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009. 10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007. 11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. 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, 1982.

Course L1820: System Simulation	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Dr. Stefan Wischhusen
Language	DE
Cycle	WiSe
Content	<p>Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.</p> <ul style="list-style-type: none"> • 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	<p>[1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7</p> <p>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.</p> <p>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.</p> <p>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.</p> <p>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011.</p>

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

Course L0379: Ceramics Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Dr. Rolf Janßen
Language	DE/EN
Cycle	WiSe
Content	<p>Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominately on powder-based processing, e.g. "powder-metallurgical techniques and sintering (solid state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed. Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.</p> <p>Content:</p> <ol style="list-style-type: none"> 1. Introduction 2. Raw materials 3. Powder fabrication 4. Powder processing 5. Shape-forming processes 6. Densification, sintering 7. Glass and Cement technology 8. Ceramic-metal joining techniques <p>Inhalt:</p>
Literature	<p>W.D. Kingery, „Introduction to Ceramics“, John Wiley & Sons, New York, 1975</p> <p>ASM Engineering Materials Handbook Vol.4 „Ceramics and Glasses“, 1991</p> <p>D.W. Richerson, „Modern Ceramic Engineering“, Marcel Decker, New York, 1992</p> <p>Skript zur Vorlesung</p>

Module M1279: MED II: Introduction to Biochemistry and Molecular Biology				
Courses				
Title	Introduction to Biochemistry and Molecular Biology (L0386)	Typ	Lecture	Hrs/wk 2 CP 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 			
<i>Skills</i>	The students can <ul style="list-style-type: none"> recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 			
Personal Competence				
<i>Social Competence</i>	The students can participate in discussions in research and medicine on a technical level.			
<i>Autonomy</i>	The students can develop understanding of topics from the course, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 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 Biomechanics: Compulsory Data Science: Specialisation Medicine: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			
Course L0386: Introduction to Biochemistry and Molecular Biology				
Typ	Lecture			
Hrs/wk	2			
CP	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Hans-Jürgen Kreienkamp			
Language	DE			
Cycle	WiSe			
Content				
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008			

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

Course L0593: Biomaterials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	EN
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (Importance, nomenclature, relations) 2. Biological materials <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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 <p>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.</p>
Literature	<p>Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.</p> <p>Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.</p> <p>Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.</p> <p>Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.</p> <p>Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.</p> <p>Wintermantel, E. und Ha, S.-W : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.</p>

Module M0808: Finite Elements Methods				
Courses				
Title		Typ	Hrs/wk	CP
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.			
<i>Skills</i>	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
Personal Competence				
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.			
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 scale	120 min			
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory			

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Otto von Estorff
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

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

Module M1342: Polymers				
Courses				
Title	Typ	Hrs/wk	CP	
Structure and Properties of Polymers (L0389)	Lecture	2	3	
Processing and design with polymers (L1892)	Lecture	2	3	
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	<p><i>Knowledge</i> Students can use the knowledge of plastics and define the necessary testing and analysis.</p> <p>They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).</p> <p><i>Skills</i> Students are capable of</p> <ul style="list-style-type: none"> - using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. - selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance. <p>Personal Competence</p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> - arrive at funded work results in heterogenous groups and document them. - provide appropriate feedback and handle feedback on their own performance constructively. <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity. 			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	180 min			
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory 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 Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory			

Course L0389: Structure and Properties of Polymers	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Hans Wittich
Language	DE
Cycle	WiSe
Content	<ul style="list-style-type: none"> - Structure and properties of polymers - Structure of macromolecules Constitution, Configuration, Conformation, Bonds, Synthesis, Molecular weight distribution - Morphology amorph, crystalline, blends - Properties Elasticity, plasticity, viscoelasticity - Thermal properties - Electrical properties - Theoretical modelling - Applications
Literature	Ehrenstein: Polymer-Werkstoffe, Carl Hanser Verlag

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

Module M0632: Regenerative Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Regenerative Medicine (L0347)		Seminar	2	3
Lecture Tissue Engineering - Regenerative Medicine (L1664)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.			
	The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic underlying principles of the discussed topics.			
<i>Skills</i>	After successful completion of the module students are			
	<ul style="list-style-type: none"> • able to use medical databases for acquiring and presentation of relevant up-to-date data independently • able to present their work results in the form of presentations • able to carry out basic cell culture methods and the corresponding analysis independently • able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 			
Personal Competence				
<i>Social Competence</i>	Students are able to work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and to defend them.			
	Students are able to reflect their work orally and discuss it with other students and teachers.			
<i>Autonomy</i>	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persons independently including a presentation of the results.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / protocol for lecture series
Examination	Presentation			
Examination duration and scale	Oral presentation + discussion (30 min)			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			

Course L0347: Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE
Cycle	WiSe
Content	<p>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:</p> <ul style="list-style-type: none"> • Introduction (historical development, examples for medical and technical applications, commercial aspects) • 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 <p>The fundamentals will be presented by the lecturers.</p> <p>The "state of the art" of specific applications will be exploited by the students based on selected papers and presented during the course.</p>
Literature	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum ; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Course L1664: Lecture Tissue Engineering - Regenerative Medicine	
Typ	Seminar
Hrs/wk	2
CP	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	<p>Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716</p> <p>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</p>

Module M1333: BIO I: Implants and Fracture Healing				
Courses				
Title	Typ	Hrs/wk	CP	
Implants and Fracture Healing (L0376)	Lecture	2	3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.			
Personal Competence				
<i>Social Competence</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
<i>Autonomy</i>	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 scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> 1. Introduction (history, definitions, background importance) 2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius) 3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 5.1 Basics and biology of fracture repair 5.2 Clinical principals and terminology of fracture treatment 5.3 Biomechanics of fracture treatment <ol style="list-style-type: none"> 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	<p>Cochran V.B.: Orthopädische Biomechanik</p> <p>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics</p> <p>White A.A., Panjabi M.M.: Clinical biomechanics of the spine</p> <p>Nigg, B.: Biomechanics of the musculo-skeletal system</p> <p>Schiebler T.H., Schmidt W.: Anatomie</p> <p>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat</p>

Module M0630: Robotics and Navigation in Medicine				
Courses				
Title		Typ	Hrs/wk	CP
Robotics and Navigation in Medicine (L0335)		Lecture	2	3
Robotics and Navigation in Medicine (L0338)		Project Seminar	2	2
Robotics and Navigation in Medicine (L0336)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • principles of math (algebra, analysis/calculus) • principles of programming, e.g., in Java or C++ • solid R or Matlab skills 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations.			
<i>Skills</i>	The students are able to design and evaluate navigation systems and robotic systems for medical applications.			
Personal Competence				
<i>Social Competence</i>	The students discuss the results of other groups, provide helpful feedback and can incorporate feedback into their work.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Written elaboration	
	Yes	10 %	Presentation	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0335: Robotics and Navigation in Medicine	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> - kinematics - calibration - tracking systems - navigation and image guidance - motion compensation <p>The seminar extends and complements the contents of the lecture with respect to recent research results.</p>
Literature	<p>Spong et al.: Robot Modeling and Control, 2005</p> <p>Troccaz: Medical Robotics, 2012</p> <p>Further literature will be given in the lecture.</p>

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

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

Module M1384: Case Studies for Regenerative Medicine and Tissue Engineering			
Courses			
Title	Typ	Hrs/wk	CP
Case Studies for Regenerative Medicine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i> <i>Skills</i>			
Personal Competence <i>Social Competence</i> <i>Autonomy</i>			
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42		
Credit points	6		
Course achievement	None		
Examination	Presentation		
Examination duration and scale	45 min		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory 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	
Typ	Seminar
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	
Literature	

Module M0634: Introduction into Medical Technology and Systems				
Courses				
Title		Typ	Hrs/wk	CP
Introduction into Medical Technology and Systems (L0342)		Lecture	2	3
Introduction into Medical Technology and Systems (L0343)		Project Seminar	2	2
Introduction into Medical Technology and Systems (L1876)		Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.			
<i>Skills</i>	The students are able to evaluate systems and medical devices in the context of clinical applications.			
Personal Competence				
<i>Social Competence</i>	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	10 %	Presentation	
	Yes	10 %	Written elaboration	
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

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

Course L1876: Introduction into Medical Technology and Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> - imaging systems - computer aided surgery - medical sensor systems - medical information systems - regulatory affairs - standard in medical technology <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonlinear Dynamics				
Courses				
Title		Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Calculus • Linear Algebra • Engineering Mechanics 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
<i>Skills</i>	Students are able to apply existing methods and procedures of Nonlinear Dynamics and to develop novel methods and procedures.			
Personal Competence				
<i>Social Competence</i>	Students can reach working results also in groups.			
<i>Autonomy</i>	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	2 Hours			
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

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

Module M0761: Semiconductor Technology				
Courses				
Title	Typ	Hrs/wk	CP	
Semiconductor Technology (L0722)	Lecture	4	4	
Semiconductor Technology (L0723)	Practical Course	2	2	
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, material science and semiconductor devices			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able			
	<ul style="list-style-type: none"> to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows. 			
<i>Skills</i>	Students are capable			
	<ul style="list-style-type: none"> 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 semiconductor devices. 			
Personal Competence				
<i>Social Competence</i>	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.			
<i>Autonomy</i>	None			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory			

Course L0722: Semiconductor Technology	
Typ	Lecture
Hrs/wk	4
CP	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 style="list-style-type: none"> • Introduction (historical view and trends in microelectronics) • Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) • Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) • Wafer fabrication (process flow, specification, SOI) • Fabrication processes • Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) • Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) • Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) • Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching, backspattering, ion milling, chemical dry etching, RIE, sidewall passivation) • Process integration (CMOS process, bipolar process) • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact: wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	<p>S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons</p> <p>S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons</p> <p>U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag</p> <p>H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag</p> <p>K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin</p> <p>S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press</p> <p>P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill</p>

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

Module M0835: Humanoid Robotics					
Courses					
Title	Typ	Hrs/wk	CP		
Humanoid Robotics (L0663)	Seminar	2	2		
Module Responsible	Patrick Götttsch				
Admission Requirements	None				
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Introduction to control systems • Control theory and design 				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence	<ul style="list-style-type: none"> • Students can explain humanoid robots. • Students learn to apply basic control concepts for different tasks in humanoid robotics. 				
<i>Knowledge</i>					
<i>Skills</i>					<ul style="list-style-type: none"> • Students acquire knowledge about selected aspects of humanoid robotics, based on specified literature • Students generalize developed results and present them to the participants • Students practice to prepare and give a presentation
Personal Competence					
<i>Social Competence</i>	<ul style="list-style-type: none"> • Students are capable of developing solutions in interdisciplinary teams and present them • They are able to provide appropriate feedback and handle constructive criticism of their own results 				
<i>Autonomy</i>	<ul style="list-style-type: none"> • Students evaluate advantages and drawbacks of different forms of presentation for specific tasks and select the best solution • Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students, such that a scientific discussion develops 				
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28				
Credit points	2				
Course achievement	None				
Examination	Presentation				
Examination duration and scale	30 min				
Assignment for the Following Curricula	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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 Robotics and Computer Science: Elective Compulsory				

Course L0663: Humanoid Robotics	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Patrick Götttsch
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Grundlagen der Regelungstechnik • Control systems theory and design
Literature	- B. Siciliano, O. Khatib. "Handbook of Robotics. Part A: Robotics Foundations", Springer (2008).

Module M0838: Linear and Nonlinear System Identification				
Courses				
Title		Typ	Hrs/wk	CP
Linear and Nonlinear System Identification (L0660)		Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Discrete-time systems • Linear algebra, singular value decomposition • Basic knowledge about stochastic processes 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • Students can explain the general framework of the prediction error method and its application to a variety of linear and nonlinear model structures • They can explain how multilayer perceptron networks are used to model nonlinear dynamics • They can explain how an approximate predictive control scheme can be based on neural network models • They can explain the idea of subspace identification and its relation to Kalman realisation theory 			
<i>Knowledge</i>				
<i>Skills</i>	<ul style="list-style-type: none"> • Students are capable of applying the prediction 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 applying subspace algorithms to the experimental identification of linear models for dynamic systems • They can do the above using standard software tools (including the Matlab System Identification Toolbox) 			
Personal Competence	<p><i>Social Competence</i> Students can work in mixed groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0660: Linear and Nonlinear System Identification	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Prediction error method • Linear and nonlinear model structures • Nonlinear model structure based on multilayer perceptron network • Approximate predictive control based on multilayer perceptron network model • Subspace identification
Literature	<ul style="list-style-type: none"> • Lennart Ljung, System Identification - Theory for the User, Prentice Hall 1999 • M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Neural Networks for Modeling and Control of Dynamic Systems, Springer Verlag, London 2003 • T. Kailath, A.H. Sayed and B. Hassibi, Linear Estimation, Prentice Hall 2000

Module M0840: Optimal and Robust Control				
Courses				
Title		Typ	Hrs/wk	CP
Optimal and Robust Control (L0658)		Lecture	2	3
Optimal and Robust Control (L0659)		Recitation Section (small)	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Classical control (frequency response, root locus) • State space methods • Linear algebra, singular value decomposition 			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"> • 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 constraints. • They can explain how an LQG design problem can be formulated as special case of an H2 design problem. • They can explain how model uncertainty can be represented in a way that lends itself to robust controller design • They can explain how - based on the small gain theorem - a robust controller can guarantee stability and performance for an uncertain plant. • They understand how analysis and synthesis conditions on feedback loops can be represented as linear matrix inequalities. 			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence	<ul style="list-style-type: none"> • Students are capable of designing and tuning LQG controllers for multivariable plant models. • They are capable of representing a H2 or H-infinity design problem in the form of a generalized plant, and of using standard software tools for solving it. • They are capable of translating time and frequency domain specifications for control loops into constraints on closed-loop sensitivity functions, and of carrying out a mixed-sensitivity design. • They are capable of constructing an LFT uncertainty model for an uncertain system, and of designing a mixed-objective robust controller. • They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard LMI-solvers for solving them. • They can carry out all of the above using standard software tools (Matlab robust control toolbox). 			
<i>Social Competence</i>	Students can work in small groups on specific problems to arrive at joint solutions.			
<i>Autonomy</i>	Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory			

Course L0658: Optimal and Robust Control	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Optimal regulator problem with finite time horizon, Riccati differential equation • Time-varying and steady state solutions, algebraic Riccati equation, Hamiltonian system • Kalman's identity, phase margin of LQR controllers, spectral factorization • Optimal state estimation, Kalman filter, LQG control • Generalized plant, review of LQG control • Signal and system norms, computing H2 and H∞ norms • Singular value plots, input and output directions • Mixed sensitivity design, H∞ loop shaping, choice of weighting filters • Case study: design example flight control • Linear matrix inequalities, design specifications as LMI constraints (H2, H∞ and pole region) • Controller synthesis by solving LMI problems, multi-objective design • Robust control of uncertain systems, small gain theorem, representation of parameter uncertainty
Literature	<ul style="list-style-type: none"> • Werner, H., Lecture Notes: "Optimale und Robuste Regelung" • Boyd, S., L. El Ghaoui, E. Feron and V. Balakrishnan "Linear Matrix Inequalities in Systems and Control", SIAM, Philadelphia, PA, 1994 • Skogestad, S. and I. Postlewaite "Multivariable Feedback Control", John Wiley, Chichester, England, 1996 • Strang, G. "Linear Algebra and its Applications", Harcourt Brace Jovanovic, Orlando, FA, 1988 • Zhou, K. and J. Doyle "Essentials of Robust Control", Prentice Hall International, Upper Saddle River, NJ, 1998

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

Module M0855: Marketing (Sales and Services / Innovation Marketing)			
Courses			
Title	Typ	Hrs/wk	CP
Marketing of Innovations (L2009)	Lecture	4	4
PBL Marketing of Innovations (L0862)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian L�uthje		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"> • Module International Business • 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) • Understanding the differences between 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	<p><i>Knowledge</i> Students will have gained a deep understanding of</p> <ul style="list-style-type: none"> • Specific characteristics in the marketing of innovative products and services • Approaches for analyzing the current market situation and the future market development • The gathering of information about future customer needs and requirements • Concepts and approaches to integrate lead users and their needs into product and service development processes • Approaches and tools for ensuring customer-orientation in the development of new products and innovative 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 <p><i>Skills</i> Based on the acquired knowledge students will be able to:</p> <ul style="list-style-type: none"> • 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 • Make strategic sales decisions for products and services (i.e. selection of sales channels) • Apply methods of sales force management (i.e. customer value analysis) 		
Personal Competence	<p><i>Social Competence</i> The students will be able to</p> <ul style="list-style-type: none"> • 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 <p><i>Autonomy</i> The students will be able to</p> <ul style="list-style-type: none"> • 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	Independent Study Time 110, Study Time in Lecture 70		
Credit points	6		
Course achievement	None		
Examination	Subject theoretical and practical work		
Examination duration and scale	Written elaboration, exercises, presentation, oral participation		
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

Course L2009: Marketing of Innovations	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>I. Introduction</p> <ul style="list-style-type: none"> Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing) <p>II. Methods and approaches of strategic marketing planning</p> <ul style="list-style-type: none"> patterns of industrial development, patent and technology portfolios <p>III. Strategic foresight and scenario analysis</p> <ul style="list-style-type: none"> objectives and challenges of strategic foresight, scenario analysis, Delphi method <p>IV. User innovations</p> <ul style="list-style-type: none"> Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis <p>V. Customer-oriented Product and Service Engineering</p> <ul style="list-style-type: none"> Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting <p>VII. Pricing</p> <ul style="list-style-type: none"> Basics of Pricing, Value-based pricing, Pricing models <p>VIII. Sales Management</p> <ul style="list-style-type: none"> Basics of Sales Management, Assessing Customer Value, Planning Customer Visits <p>IX. Communications</p> <ul style="list-style-type: none"> Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	<p>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).</p> <p>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGraw Hill, Boston et al., 2008</p> <p>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.</p> <p>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill</p> <p>Tidd, J. & Hull, Frank M. (Editors) (2007) Service Innovation, London</p> <p>Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press</p>

Course L0862: PBL Marketing of Innovations	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	<p>This PBL course is segregated into two afternoon sessions. This course 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.</p>
Literature	

Module M1143: Applied Design Methodology in Mechatronics				
Courses				
Title		Typ	Hrs/wk	CP
Applied Design Methodology in Mechatronics (L1523)		Lecture	2	2
Applied Design Methodology in Mechatronics (L1524)		Project-/problem-based Learning	3	4
Module Responsible	Prof. Thorsten Kern			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques			
<i>Skills</i>	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.			
Personal Competence				
<i>Social Competence</i>	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.			
<i>Autonomy</i>	Students are enabled to optimize the design and development process according to the target and topic of the design			
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Subject theoretical and practical work			
Examination duration and scale	30 min Presentation for a group design-work			
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory			

Course L1523: Applied Design Methodology in Mechatronics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Systematic analysis and planning of the design process for products combining a multitude of disciplines • Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) • Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, ... - Applications in examples all around mechatronics topics) • Several design-supporting methods and tools (functional structures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continuous integration and testing, ...) • Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparison), dealing with uncertainties, decision-making • Value-analysis • Derivation of architectures and architectural management • Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) • Project-execution methods (Scrum, Kanbaan, ...) • Presentation-skills • Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) • Evaluation of selected methods at practical examples in small teams
Literature	<ul style="list-style-type: none"> • Definition folgt... • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 • VDI-Richtlinien: 2206; 2221ff

Course L1524: Applied Design Methodology in Mechatronics	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	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 M0938: Bioprocess Engineering - Fundamentals				
Courses				
Title		Typ	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamentals (L0842)		Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental Practical Course (L0843)		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", module "fundamentals for process engineering"			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
<i>Skills</i>	After successful completion of this module, students should be able to <ul style="list-style-type: none"> describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 			
Personal Competence				
<i>Social Competence</i>	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.			
<i>Autonomy</i>	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	5 %	Subject	theoretical and practical work
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory			

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ul style="list-style-type: none"> • Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, different types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of substrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuous bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, centrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p>

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	<ol style="list-style-type: none"> 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	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	<p>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.</p> <p>The students document their experiments and results in a protocol.</p>
Literature	Skript

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

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

Module M1280: MED II: Introduction to Physiology			
Courses			
Title		Typ	Hrs/wk
Introduction to Physiology (L0385)		Lecture	2
			CP
			3
Module Responsible	Dr. Roger Zimmermann		
Admission Requirements	None		
Recommended Previous Knowledge	None		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can <ul style="list-style-type: none"> describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 		
<i>Skills</i>	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development of forces and vital functions) and relate them to similar technical systems.		
Personal Competence			
<i>Social Competence</i>	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.		
<i>Autonomy</i>	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 scale	60 minutes		
Assignment for the Following Curricula	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p> <p>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>		

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

Module M1278: MED I: Introduction to Radiology and Radiation Therapy				
Courses				
Title	Typ	Hrs/wk	CP	
Introduction to Radiology and Radiation Therapy (L0383)	Lecture	2	3	
Module Responsible	Prof. Ulrich Carl			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	<p>Therapy</p> <p>The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.</p> <p>The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).</p> <p>The students can describe the patients' passage from their initial admittance through to follow-up care.</p> <p>Diagnostics</p> <p>The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).</p> <p>The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.</p> <p>The students can choose the right treatment method depending on the patient's clinical history and needs.</p> <p>The student can explain the influence of technical errors on the imaging techniques.</p> <p>The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.</p>			
<i>Skills</i>	<p>Therapy</p> <p>The students can distinguish curative and palliative situations and motivate why they came to that conclusion.</p> <p>The students can develop adequate therapy concepts and relate it to the radiation biological aspects.</p> <p>The students can use the therapeutic principle (effects vs adverse effects)</p> <p>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).</p> <p>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).</p> <p>Diagnostics</p> <p>The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.</p> <p>The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.</p>			
Personal Competence				
<i>Social Competence</i>	<p>The students can assess the special social situation of tumor patients and interact with them in a professional way.</p> <p>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.</p>			
<i>Autonomy</i>	<p>The students can apply their new knowledge and skills to a concrete therapy case.</p> <p>The students can introduce younger students to the clinical daily routine.</p> <p>The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.</p>			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 minutes			
Assignment for the Following Curricula	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p>			

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

Course L0383: Introduction to Radiology and Radiation Therapy

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ulrich Carl, Prof. Thomas Vestring
Language	DE
Cycle	SoSe
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments
Literature	<ul style="list-style-type: none"> • "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. Despopoulos- 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		Typ	Hrs/wk CP
Artificial Joint Replacement (L1306)		Lecture	2 3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	The students can name the different kinds of artificial limbs.		
<i>Skills</i>	The students can explain the advantages and disadvantages of different kinds of endoprotheses.		
Personal Competence			
<i>Social Competence</i>	The students are able to discuss issues related to endoprothese with student mates and the teachers.		
<i>Autonomy</i>	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	SoSe
Content	<p>Inhalt (deutsch)</p> <ol style="list-style-type: none"> 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	<p>Literatur:</p> <p>Kapandji, I.: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.</p> <p>Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994</p> <p>Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.</p> <p>Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.</p> <p>Sobotta und Netter für Anatomie der Gelenke</p>

Module M0845: Feedback Control in Medical Technology			
Courses			
Title		Typ	Hrs/wk
Feedback Control in Medical Technology (L0664)		Lecture	2
			CP
			3
Module Responsible	Johannes Kreuzer		
Admission Requirements	None		
Recommended Previous Knowledge	Basics in Control, Basics in Physiology		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
<i>Knowledge</i>	<p>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.</p> <p>Internal control loops of the human body will be discussed in the same way like the design of external closed loop system for example in for anesthesia control.</p> <p>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.</p>		
<i>Skills</i>	Application of modeling, identification, control technology in the field of medical technology.		
Personal Competence			
<i>Social Competence</i>	Students can develop solutions to specific problems in small groups and present their results		
<i>Autonomy</i>	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 scale	20 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective 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: Compulsory		

Course L0664: Feedback Control in Medical Technology	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Johannes Kreuzer, Christian Neuhaus
Language	DE
Cycle	SoSe
Content	<p>Always viewed from the engineer's point of view, the lecture is structured as follows:</p> <ul style="list-style-type: none"> • 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 <p>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.</p>
Literature	<ul style="list-style-type: none"> • 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.

Module M0635: Medical Technology Lab				
Courses				
Title		Typ	Hrs/wk	CP
Medical Technology Lab (L1096)		Project-/problem-based Learning	6	6
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous Knowledge	sound programming skills (Java / C++) skills in R/Matlab 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				
<i>Knowledge</i>	The students recognize the complexity of medical technology and can explain, which methods are appropriate to solve a problem at hand.			
<i>Skills</i>	The students are able to analyze and solve problems in medical technology.			
Personal Competence				
<i>Social Competence</i>	The students can define project aims and scope and organize the project as team work. They can present their results in an appropriate manner.			
<i>Autonomy</i>	The students take responsibility for their tasks and coordinate their individual work with other group members. They deliver their work on time. They independently acquire additional knowledge by doing a specific literature research.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Group discussion	
Examination	Written elaboration			
Examination duration and scale	approx. 8 pages, time frame: over the course of the semester			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
Course L1096: Medical Technology Lab				
Typ	Project-/problem-based Learning			
Hrs/wk	6			
CP	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 M0832: Advanced 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 Knowledge	H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> • Students can explain the advantages and shortcomings of the classical gain scheduling approach • They can explain the representation of nonlinear systems in the form of quasi-LPV systems • They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions • They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems • They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures <p><i>Skills</i></p> <ul style="list-style-type: none"> • Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems • They can explain the convergence properties of first order consensus protocols • They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models • Students can explain concepts behind linear and qLPV Model Predictive Control (MPC) • Students can construct LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models • They can use standard software tools (Matlab robust control toolbox) for these tasks • Students can design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided • Students can design MPC controllers for linear and non-linear systems using Matlab tools <p>Personal Competence</p> <p><i>Social Competence</i> Students can work in small groups and arrive at joint results.</p> <p><i>Autonomy</i> Students can find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.</p>		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56		
Credit points	6		
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory 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	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> • Linear Parameter-Varying (LPV) Gain Scheduling <ul style="list-style-type: none"> - 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 <ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> • 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0548: Bioelectromagnetics: Principles and Applications				
Courses				
Title		Typ	Hrs/wk	CP
Bioelectromagnetics: Principles and Applications (L0371)		Lecture	3	5
Bioelectromagnetics: Principles and Applications (L0373)		Recitation Section (small)	2	1
Module Responsible	Prof. Christian Schuster			
Admission Requirements	None			
Recommended Previous Knowledge	Basic principles of physics			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
<i>Knowledge</i>	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.			
<i>Skills</i>	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence				
<i>Social Competence</i>	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).			
<i>Autonomy</i>	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 Time in Lecture 70			
Credit points	6			
Course achievement	Compulsory	Bonus	Form	Description
	Yes	None	Presentation	
Examination	Oral exam			
Examination duration and scale	45 min			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory			

Course L0371: Bioelectromagnetics: Principles and Applications	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Module M-002: Master Thesis

Courses

Title	Typ	Hrs/wk	CP
Module Responsible	Professoren der TUHH		
Admission Requirements	<ul style="list-style-type: none"> According to General Regulations §21 (1): <p>At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.</p>		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence <i>Knowledge</i>	<ul style="list-style-type: none"> The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them. The students can place a research task in their subject area in its context and describe and critically assess the state of research. 		
Skills	<p>The students are able:</p> <ul style="list-style-type: none"> To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. To develop new scientific findings in their subject area and subject them to a critical assessment. 		
Personal Competence <i>Social Competence</i>	<p>Students can</p> <ul style="list-style-type: none"> Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly. 		
<i>Autonomy</i>	<p>Students are able:</p> <ul style="list-style-type: none"> To structure a project of their own in work packages and to work them off accordingly. To work their way in depth into a largely unknown subject and to access the information required for them to do so. To apply the techniques of scientific work comprehensively in research of their own. 		
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0		
Credit points	30		
Course achievement	None		
Examination	Thesis		
Examination duration and scale	According to General Regulations		
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory		

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