Module Manual

Master of Science (M.Sc.)

Biomedical Engineering

Cohort: Winter Term 2018

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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;

 \bullet To systematically reflect non-technical implications of engineering activity and responsibly integrate into their actions.

Core qualification

Module M0523	3: 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	
Knowledge	 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.
Skills	 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	
Social Competence	 Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	 Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

Courses

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

Module M0524: Nontechnical Elective Complementary Courses for Master

	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	
Professional	

Competence

The Nontechnical Academic Programms (NTA)

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

The Learning Architecture

consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.

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

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

Teaching and Learning Arrangements

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

Knowledge Fields of Teaching

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

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

The Competence Level

of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.

This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.

Specialized Competence (Knowledge)

Students can

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

Professional Competence (Skills)

In selected sub-areas students can

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

Personal Competence

Skills

Personal Competences (Social Skills)

Students will be able

- to learn to collaborate in different manner,
- to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,
- to express themselves competently, in a culturally appropriate and gendersensitive 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.

Social Competence

Personal Competences (Self-reliance)

Students are able in selected areas

to reflect on their own profession and professionalism in the context of real-

Autonomy	 life fields of application to organize themselves and their own learning processes to reflect and decide questions in front of a broad education background to communicate a nontechnical item in a competent way in writen form or verbaly to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

Courses

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

Module M1173	3: Applied	d Statis	tics				
Courses							
Title	- 4.			Тур	Hrs/wk	СР	
Applied Statistics (L15)				Lecture Project-/problem-	2	3	
Applied Statistics (L15	36)			based Learning	2	2	
Applied Statistics (L15)	85)			Recitation Sectio (small)	ⁿ 1	1	
Module Responsible	Prof. Michael	Morlock					
Admission Requirements	None						
Recommended Previous Knowledge	Basic knowle	dge of sta	tistical methods				
Educational Objectives	After taking p	oart succes	ssfully, students h	ave reached the follo	wing learn	ing results	
Professional Competence							
Knowledge	Students can explain the statistical methods and the conditions of their use.						
Skills		Students are able to use the statistics program to solve statistics problems and to interpret and depict the results					
Personal Competence	'	·					
Social Competence	Team Work, joined presentation of results						
Autonomy	To understar	To understand and interpret the question and solve					
Workload in Hours	Independent	Study Tim	e 110, Study Time	e in Lecture 70			
Credit points	6						
Course achievement	Yes 1	Bonus None	Form Written elaborati	Descript ion	tion		
Examination	Written exan	า					
Examination duration and scale	90 minutes, 2	28 questio	ns				
the Following	Compulsory Mechatronics Mechatronics Biomedical E Product Dev Compulsory Theoretical Compulsory	s: Specialis s: Specialis ngineering velopment, Mechanica Mechanica	sation System Des sation Intelligent S g: Core qualificatio , Materials and	ent: Specialisation ign: Elective Compulsystems and Robotics on: Compulsory Production: Core echnical Complement ecialisation Bio- and	sory : Elective (qualification	Compulsory on: Elective se: Elective	

Course L1584: App	lied Statistics
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
	The goal is to introduce students to the basic statistical methods and their application to simple problems. The topics include:
	Chi square test
	Simple regression and correlation
	Multiple regression and correlation
Content	One way analysis of variance
33113111	Two way analysis of variance
	Discriminant analysis
	Analysis of categorial data
	Chossing the appropriate statistical method
	Determining critical sample sizes
Literature	Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6

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

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

Courses								
Title						Тур	Hrs/wk	СР
Medical Imaging Syste						Lecture	4	6
Module Responsible		chael G	rass					
Admission Requirements	None							
Recommended Previous Knowledge	none							
Educational Objectives	After	taking p	art succe	essfully,	students h	ave reached	the following lear	ning results
Professional Competence								
Knowledge	• • • • Descr	imagin Explair system Explair with th Name contras Explair charac Explair	pe the sign system in how the sign and appeared and dests; in how specification to the system of the system is the system of the	is; e systen n; oly the p nental pl scribe atial an e images mage rec	n compone hysical pro hysical equ the physic d tempora s generated constructio	nts and the cesses that neations; cal effects resolution od; neethods ar	ponents of the inverall system of make imaging postequired to general be influenced to general erent systems.	the imagir sible and us erate imag and how
Skills		mather o	matical of Calculate or physic Determir and tempe Explain to clinical a	r physic the par al equat he the in poral res he impo pplicatio	al equation rameters of cions; fluence of colution of interesting or cons;	is required; f imaging sys different syst maging syste	ssign to the syste stems using the r em components o ms; ging systems for	nathemation
Dowsonal	Select	. a suita	bie iiilag	ilig syste	eiii ioi aii a	іррпсацоп.		
Personal Competence								
Social Competence								
Autonomy	•		tand whi				nedical imaging; a measuring sy:	stem can I
Workload in Hours	Indep	endent :	Study Tir	ne 124,	Study Time	e in Lecture 5	6	
Credit points			·	·				
Course	None							

Examination	Written exam
Examination duration and scale	
Assignment for the Following Curricula	Compulsory Product Development Materials and Production: Specialisation Materials: Flective

Course L0819: Medical Imaging Systems	
Тур	Lecture
Hrs/wk	4
СР	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dr. Michael Grass, Dr. Tim Nielsen, Dr. Sven Prevrhal, Frank Michael Weber
Language	DE
Cycle	SoSe
Content	
Literature	Primary book: 1. P. Suetens, "Fundamentals of Medical Imaging", Cambridge Press Secondary books: - A. Webb, "Introduction to Biomedical Imaging", IEEE Press 2003. - W.R. Hendee and E.R. Ritenour, "Medical Imaging Physics", Wiley-Liss, New York, 2002. - H. Morneburg (Edt), "Bildgebende Systeme für die medizinische Diagnostik", Erlangen: Siemens Publicis MCD Verlag, 1995. - O. Dössel, "Bildgebende Verfahren in der Medizin", Springer Verlag Berlin, 2000.

Module M1179	9: Medical Basics and	l Pathology		
Courses				
Title Medical Basics and Pathology I (L1599) Medical Basics and Pathology II (L1600)		Typ Lecture Lecture	Hrs/wk 2 2 2	CP 2 2
Medical Basics and Pat Module Responsible		Lecture		2
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully,	students have reached the	following learn	ing results
Professional Competence Knowledge Skills				
Personal Competence				
Social Competence Autonomy Workload in Hours	Independent Study Time 96, S	Study Time in Lecture 84		
Credit points		ready Time in Lecture 04		
Course achievement	None			
Examination	Written exam			
Examination duration and scale	120 minutes			
Assignment for the Following Curricula	Biomedical Engineering: Core	qualification: Compulsory		

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

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

Course L1602: Medical Basics and Pathology III	
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Dominic Wichmann
Language	DE
Cycle	WiSe
Content	 a) Basic understanding of the pathology/pathophysiology of cardiac diseases and their stage-adapted treatments: coronary heart disease, myocardial infarction, mitral valve insufficiencies, aortic valve stenosis b) Basic understanding of the pathology/pathophysiology of pulmonary diseases and their stage-adapted treatments: asthma, chronic obstructive pulmonary disease, pneumonia, bronchial cancer c) Basic understanding of infectious diseases, immune-system and autoimmune diseases
Literature	Skript zur Vorlesung.

Courses					
Γitle		Тур	Hrs/wk	СР	
Practical Course Produ [L1566)	ct Development, Materials and Production	Practical Course	6	6	
Module Responsible	Prof. Wolfgang Hintze				
Admission Requirements	None				
•	Product Development:				
	Lectures: Mechanics I-IIILectures: Integrated Product Deve	elopment I incl. CAD	practical tra	aining	
	Materials:				
Recommended Previous Knowledge	Composites, Manufacturing of Pol	erials Testing es of Polymers, Str	ucture and F		
_	Production:				
	 Lecture: Production Engineering Lectures: Forming and Cutting 1 design Lectures: Machine Tools and Robo 		s of product	ion proces	
Educational Objectives	After taking part successfully, students	have reached the fo	llowing learr	ning results	
Professional Competence					
competence	Students can				
Knowledge	 represent more complex context describe functionality of mod machine technologies. 			tations an	
	Students are capable of				
Skills	 applying theoretical knowledge for applying provided experimental if fields of study. analyzing and evaluating experimental applying modern measurement in 	methods for examin	ing contexts		
Personal Competence	Students can				
Social Competence	carry out and document experimepresent and discuss experimenta			rent fields (

Autonomy	 Students are able to 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		
Тур	Practical Course	
Hrs/wk	6	
СР	6	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84	
Lecturer	Prof. Wolfgang Hintze, Prof. Josef Schlattmann, Prof. Dieter Krause, Prof. Claus Emmelmann, Prof. Uwe Weltin, Prof. Bodo Fiedler, Prof. Hermann Lödding, Prof. Michael Morlock, Prof. Gerold Schneider, Prof. Thorsten Schüppstuhl, Prof. Otto von Estorff, Prof. Jörg Weißmüller	
Language	DE	
Cycle	SoSe	
Content	 Modal analysis - experimental and computational Appropriate design in engineering Characterization of rubbery-elastic materials Stick-Slip-Analysis at friction and wear test station Materials: Property profiles of steel Actuators for modern fuel injection systems - synthesis and properties Processing, properties and structure of thermoplastic polymers and its composites Tribology in joints Production: Optimization of welding process parameters for hybrid plasma laser welding 	
	 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 Clinic	al Internship		
Courses				
Title Casestudies Surgery a Clinical Internship (L15	nd Internal Medicine (L1603) 587)	Typ Seminar Practical Course	Hrs/wk 5 1	CP 5 1
Kesponsible				
Admission Requirements	None			
	The lectures addressing medica Engineering in the respective BSc P		oncentration	Biomedical
Educational Objectives	After taking part successfully, stude	ents have reached the fo	ollowing learn	ing results
Professional Competence				
	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.			
Skills	Interpreting and explaining the med	lical history and medica	al records of a	patient.
Personal Competence Social Competence Autonomy	Dealing with patients.			
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 qualit	ication: Compulsory		

Course L1603: Casestudies Surgery and Internal Medicine		
Тур	Seminar	
Hrs/wk	5	
СР	5	
Workload in Hours	Independent Study Time 80, Study Time in Lecture 70	
Lecturer	Dr. Dominic Wichmann, Dr. Johannes Kluwe	
Language		
Cycle	WiSe/SoSe	
Content	Die Fallstudien werden in einem 2-wöchentlichen Blockkurs in der Innere und Chirurgie demonstriert. Alle 1-2 Tage wechseln die Stationen hierzu gehören: Notaufnahme Intensivstation Pneumologie Gastroenterologie Kardiologie Transfusionsmedizin Poliklinik/Ambulanz Dialyse Unfallchirugie	
Literature	keine spezifische	

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

Module M1214	1: Study work
Courses	
Title	Typ Hrs/wk CP
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Master program and the specialisations.
Educational Objectives	IAHER TAKING DAN SUCCESSIUM SUNGENIS DAVE FEACHED THE IOHOWING JEARDING FESTIUS
Professional Competence	
Knowledge	 Students can explain the project as well as their autonomously gained knowledge and relate it to current issues of their field of study. They can explain the basic scientific methods they have worked with.
Skills	The students are able to autonomously solve a limited scientific task under the guidance of an experienced researcher. They can justify and explain their approach for problem solving; they can draw conclusions from their results, and then can fine ways and methods for their work. Students are capable of comparing and assessing alternative approaches with their own with regard to given criteria.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work procedure and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their peers and supervisors.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	
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	3: Intelligen	it Syst	tems in Me	dicine		
Courses						
Title Intelligent Systems in Intelligent Systems in Intelligent Systems in	Medicine (L0334)			Typ Lecture Project Semina Recitation (small)	Hrs/wk 2 r 2 Section 1	CP 3 2
Module Responsible	Prof. Alexander	Schlaefe	r			
Admission Requirements	None					
Recommended Previous Knowledge	principlesprinciples	of stoch of progr	(algebra, analys nastics ramming, Java/C nming skills		ab	
Educational Objectives	I ATTOR FAKING NAD	success	fully, students h	ave reached th	ne following learr	ning results
Professional Competence						
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.					
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.					
Personal Competence						
Social Competence	The students dis incoorporate fee	scuss the edback in	e results of othe to their work.	r groups, prov	ide helpful feedb	ack and car
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Stu	ıdy Time	110, Study Time	e in Lecture 70		
Credit points	6					
Course achievement	1 Y 🗠 S = 1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (1 (%	Form Written elaborati Presentation		escription	
Examination	Written exam					
Examination duration and scale						
	Electrical Engine	ering: S	pecialisation Med	dical Technolog	ing: Elective Com gy: Elective Comp on Systems Engi	oulsory

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

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

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

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

Module M0629	9: Intelligent Autonomous Agents and Cognitive Robotics
Courses	
_	Typ Hrs/wk CP s Agents and Cognitive Robotics (L0341) Lecture 2 4 s Agents and Cognitive Robotics (L0512) Recitation (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	
Knowledge	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition students can define decision making procedures in simple and sequential settings with and with complete access to the state of the environment. In this context students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.
Skills	Students can select an appropriate 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 situation students will apply techniques for finding different equilibria states, e.g., Nasl equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.
Personal Competence	
Social Competence	Students are able to discuss their solutions to problems with others. They communicate in English
Autonomy	Students are able of checking their understanding of complex concepts by solving varaints 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	Blomodical Enginooring: Spocialication Implants and Endoprocthocos: Eloctivol

Lecture 2 4 Independent Study Time 92, Study Time in Lecture 28 Rainer Marrone EN WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
2 4 Independent Study Time 92, Study Time in Lecture 28 Rainer Marrone EN WiSe • Definition of agents, rational behavior, goals, utilities, environment types • Adversarial agent cooperation:
Independent Study Time 92, Study Time in Lecture 28 Rainer Marrone EN WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
Rainer Marrone EN WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
Rainer Marrone EN WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
 EN WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
 WiSe Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation:
Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning 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
 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009
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Course L0512: Intelligent Autonomous Agents and Cognitive Robotics		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	WiSe	
Content	See interlocking course	
Literature	See interlocking course	

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

Courses				
Title	Тур	Hrs/wk	CP	
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Wavegu Compatibility (L1669)	uides, Antennas, and Electromagnetic	Lecture	3	4
	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
	llatory Approval of Implants (L1588)	Lecture	2	3
	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in E		Seminar	2	3
Seminar Biomedical En	gineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00	01)	Lecture	2	4
Ceramics Technology (L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation I Elective Compulsory Biomedical Engineering: Specialisation A Elective Compulsory	Medical Tec	hnology and Cont and Business Adı	rol Theory:

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

Course L1669: Intr	oduction to Waveguides, Antennas, and Electromagnetic Compatibility
Тур	Lecture
Hrs/wk	3
СР	4
	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

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

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

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

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

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

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

Course L0379: Ceramics Technology			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, St	udy Time in Lecture 28	
Examination Form	Klausur		
Examination duration and scale	90 Minuten		
Lecturer	Dr. Rolf Janßen		
Language	DE/EN		
Cycle	WiSe		
	Introduction to ceramic processing with emphasis on advanced structural ceramic The course focus predominatly on powder-based processing, e.g. "powder metauurgical techniques and sintering (soild state and liquid phase). Also, son aspects of glass and cement science as well as new developments in powderle forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.		
	Content:	1. Introduction	
	Inhalt:	2. Raw materials	
Content		3. Powder fabrication	
		4. Powder processing	
		5. Shape-forming processes	
		6. Densification, sintering	
		7. Glass and Cement technology	
		8. Ceramic-metal joining techniques	
	W.D. Kingery, "Introduction to 0	Ceramics", John Wiley & Sons, New York, 1975	
	ASM Engineering Materials Handbook Vol.4 "Ceramics and Glasses", 1991		
Literature	ture D.W. Richerson, "Modern Ceramic Engineering", Marcel Decker, New York, 1992		
	Skript zur Vorlesung		
	Skript zur voriesung		

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Wavegu Compatibility (L1669)	uides, Antennas, and Electromagnetic	Lecture	3	4
Introduction to Wavegu Compatibility (L1877)	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
Development and Regi	ulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in I	·	Seminar	2	3
Seminar Biomedical En	gineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00	01)	Lecture	2	4
Ceramics Technology (L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following lear	ning results
Professional Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the Following Curricula	owing Compulsory Riomodical Engineering: Specialisation Medical Technology and Control Theory			

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Lecture	
Hrs/wk	3	
СР	4	
	Independent Study Time 78, Study Time in Lecture 42	
Examination Form		
Examination duration and scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques	
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007) 	

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

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

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

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

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

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

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

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

Module M0746	6: Microsystem	Engineering			
Courses					
Title Microsystem Engineering (L0680) Microsystem Engineering (L0682)			Typ Lecture Project-/problem-	Hrs/wk 2 2	CP 4
			based Learning		
Module Responsible	Prof. Manfred Kasper				
Admission Requirements	LNODE				
Recommended Previous Knowledge	Basic courses in physic	cs, mathematics a	nd electric enginee	ring	
Educational Objectives	I VITAL LAKING DALL CITCO	essfully, students h	nave reached the fo	llowing learn	ing results
Professional Competence					£ NAENAC
Knowledge	The students know abo well as their applicatio			and materials	S OT MEMS
Skills		Students are able to analyze and describe the functional behaviour of MEM components and to evaluate the potential of microsystems.			
Personal Competence		-l::::			
Social Competence	Students are able to solve specific problems alone or in a group and to present th results accordingly.				
Autonomy		Students are able to acquire particular knowledge using specialized literature and t integrate and associate this knowledge with other fields.			
	Independent Study Tim	ne 124, Study Tim	e in Lecture 56		
Credit points					
Course achievement	CompulsorBonus No 10 %	Form Presentation	Descri	iption	
Examination	Written exam				
Examination duration and scale	2h				
	Electrical Engineering: Core qualification: Compulsory Computational Science and Engineering: Specialisation Systems Engineering ar Robotics: 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: Specialisation System Design: Elective Compulsory				
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
Microelectronics and Microsystems: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
Flective Compulsory

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

Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Manfred Kasper	
Language	EN	
Cycle	WiSe	
	Examples of MEMS components	
	Layout consideration	
Content	Electric, thermal and mechanical behaviour	
	Design aspects	
Literature	Wird in der Veranstaltung bekannt gegeben	

Module M075	L: Vibration Theory
Courses	
Title Vibration Theory (L070	Typ Hrs/wk CP Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	5
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to denote terms and concepts of Vibration Theory and develop them further.
Personal Competence	
Autonomy	Students can reach working results also in groups. Students are able to approach individually research tasks in Vibration Theory.
	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	
Examination duration and scale	
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: 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: Technical Complementary Course: Elective Compulsory

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

Courses					
Title			Тур	Hrs/wk	CP
Microsystems Technology	ogy (L0724)		Lecture	2	4
Microsystems Technolo	ogy (L0725)		Project-/problem- based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu				
Admission Requirements	None				
Recommended Previous Knowledge	Dacies in physics, shop	nistry, mechan	ics and semiconducto	r technology	
Educational Objectives	I ATTER TAKING NART SLICCE	essfully, studen	ts have reached the fo	ollowing lear	ning results
Professional					
Competence					
Knowledge	 to present and to explain current fabrication techniques for microstructures a especially methods for the fabrication of microsensors and microactuators, as the integration thereof in more complex systems to explain in details operation principles of microsensors and microactual and 				ators, as w
	Students are capable to analyze the feas		ation of microsystems		
Skills	to develop processto apply them.	s flows for the f	abrication of microstr	uctures and	
Personal Competence					
Social Competence	Students are able to pwell as to present and				eam work
Autonomy	None				
Workload in Hours	Independent Study Tin	ne 124, Study 1	Time in Lecture 56		
Credit points	6				
	Compulsor B onus	Form			ühren e

Course achievement	Yes Non	e Subject e practical	theoretical work	and Laborpraktikum Gruppe präs diskutiert die Th Ergebniise ihrer vor dem gesamt	entiert und eorie sowie die Labortätigkeit.
Examination	Oral exam				
Examination duration and scale					
Assignment for the Following Curricula	Technology: Electical Engine Computational State Robotics: Electical International Material Engine Elective Compulsory Biomedical Engine Elective Compulsory Biomedical Engine Elective Compul Biomedical Engine Elective Compul Biomedical Engine Elective Compul Elective Compul Elective Compul	Science and Engre Compulsory inagement and Engre Specialisory pineering: Specialisory ineering: Specialisory ineering: Specialisory ineering: Specialisory	tion Medical Telineering: Special Spec	noelectronics and echnology: Elective Cocialisation Systems E ecialisation II. Mechat Organs and Regenerants and Endoprosthal Technology and Coement and Business cation: Elective Comp	ngineering and ronics: Elective ative Medicine: neses: Elective control Theory:

Course L0724: Mici	rosystems Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
	 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

Content and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal sensor; metal oxide semiconductor gas sensor, organic conductivity 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) M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 Literature

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

T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010

G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Courses					
Title			Тур	Hrs/wk	СР
Finite Element Method	s (L0291)		Lecture	2	3
Finite Element Method	s (L0804)		Recitation (large)	Section 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 succes	sfully, students h	ave reached t	the following learr	ning results
Professional Competence					
Knowledge	The students possess a element method and ar basis of the method.				
Skills	The students are capal finite elements, assem resulting system of equ	bling the corresp			
Personal Competence					
Social Competence	Students can work in sn	nall groups on sp	ecific problem	s to arrive at joint	solutions.
Autonomy	The students are able to independently solve challenging computational problem and develop own finite element routines. Problems can be identified and the result are critically scrutinized.				
Workload in Hours	Independent Study Time	e 124, Study Time	e in Lecture 5	 6	
Credit points					
Course achievement	CompulsorBonus	Form Midterm	D	escription	
Examination	Written exam				
Examination duration and scale					
	Civil Engineering: Core of Energy Systems: Core of Aircraft Systems Engine Aircraft Systems Engin	ualification: Electering: Specialisat	ive Compulso ion Aircraft Sy	ystems: Elective C	Compulsory

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

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

Module M0814	4: Technology Managem	ent		
Courses				
Title		Тур	Hrs/wk	СР
Technology Manageme	ent (L0849)	Project-/problem- based Learning	3	3
Technology Manageme	ent Seminar (L0850)	Project-/problem- based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	INODE			
Recommended Previous Knowledge	Bachelor knowledge in business ma	nagement		
	After taking part successfully stude	ents have reached the foll	owing learn	ing results
Professional Competence				
Knowledge	 Students will gain deep insights into: Technology Timing Strategies Technology Strategies and Lifecycle Management (I/II) Technology Intelligence and Planning Technology Portfolio Management Technology Portfolio Methodology Technology Acquisition and Exploitation IP Management Organizing Technology Development Technology Organization & Management Technology Funding & Controlling 			
Skills	 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: Basic concepts, models and tools, relevant to the management of technology, R&D and innovation Innovation as a process (steps, activities and results) 			
Personal Competence				
Social Competence	Interact within a teamRaise awareness for globabl issues			
Autonomy	 Gain access to knowledge so Interpret complicated cases 	urces		

	Develop presentation skills
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	
	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory

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

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

Module M0846: Control Systems Theory and Design				
Courses				
Title Control Systems Theor Control Systems Theor		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 4 2
Module Responsible	Prof. Herbert Werner	(Sinail)		
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	After taking part successfully, stude	ents have reached	the following lear	ning results
Professional Competence				
Knowledge	 Students can explain how lift space models; they can intexternal excitation as trajected. They can explain the system their relationship to state feetomer their relationship to state feetomer they can explain the signification. They can explain observer achieve tracking and disturbation. They can extend all of the about the can explain the z-train transform. They can explain state space time systems. They can explain the experise systems, and how the iden normal equation. They can explain how a state of the can explain how	erpret the system ories in state space properties control dback and state elemence of a minimal pased state feedback ance rejection love to multi-input insform and its models and transimental identification problem tate space model	n response to inition response to inition e collability and obsestimation, respect realisation collaboration in the collaboration is and how it calculated and how it calculated by the collaboration model on of ARX model can be solved	rvability, and cively n be used to ems the Laplace els of discrete sof dynamic by solving a
Skills	 Students can transform transvice versa They can assess controllaborealisations They can design LQG control They can carry out a controutime domain, and decide whi They can identify transfer dynamic systems from expering they can carry out all these Control Toolbox, System Iden 	eility and observaluers for multivariable design both in the chis appropriate function models imental data	ability and const ole plants continuous-time for a given sampli and state spac	ruct minima and discrete- ing rate e models o
Personal Competence				
Social Competence	Students can work in small groups of Students can obtain information f			
	documentation, experiment guides)			

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

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

Courses				
		T	Here foods	CD
Title The Digital Enterprise	(1.0932)	Typ Lecture	Hrs/wk 2	CP 2
Production Planning ar		Lecture	2	2
Production Planning ar		Recitation	Section ₁	1
r roduction r idinimig di	14 GOINTON (20050)	(small) Recitation	Soction	-
Exercise: The Digital E	nterprise (L0933)	(small)	Section 1	1
Module Responsible				
Admission Requirements	LNIONA			
Recommended				
	Fundamentals of Production and (Quality Management	t	
Knowledge				
Educational Objectives		dents have reached	the following learn	ing results
Professional				
Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Children are capable of sheeping and applying models and mathods from the			
Personal Competence				
Social Competence	Students can develop joint solutio	ns in mixed teams a	and present them to	o others.
Autonomy	•		·	
Norkload in Hours	Independent Study Time 96, Stud	y Time in Lecture 84	4	
Credit points	6			
Course achievement				
	Written exam			
Examination duration and scale	180 Minuten			
	International Management and E	ngineering: Speciali	sation II. Product C)evelopmei
	and Production: Elective Compuls	ory		•
	Logistics, Infrastructure and M Elective Compulsory	obility: Specialisati	on Production an	d Logistic
	Biomedical Engineering: Specialis	ation Artificial Orga	ns and Regenerativ	ve Medicine
	Elective Compulsory			
	Biomedical Engineering: Specia	lisation Implants a	and Endoprosthes	es: Electiv
	Compulsory Biomedical Engineering: Special	isation Medical Tec	hnology and Cont	rol Theory
	Elective Compulsory	isation incarcal rec	imology and cont	1101 111001
Assignment for the Following	Diomicalcal Engineering. Specialis	sation Management	and Business Adı	ministratio
Curricula Compulsory Curricula Product Development, Materials and Production: Specialisation				
-	Development: Elective Compulsor		.ion. Specialisatic	n Produ
	Product Development, Materia		n: Specialisation	Productio
	Compulsory	and Draduction Co	ocialization Mata	ala. Elaati
	Product Development, Materials	and Production: Sp	ecialisation Materi	ais: Eiecti\
	Compulsory			
	Compulsory Theoretical Mechanical Enginee Production: Elective Compulsory	ering: Specialisation	n Product Develo	pment ar

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

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

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

Module M092:	1: Electronic Circuits for	Medical Applic	cations	
Courses				
Title Electronic Circuits for I	Medical Applications (L0696)	Typ Lecture	Hrs/wk	CP 3
Electronic Circuits for I	Medical Applications (L1056)	Recitation S (small)	Section 1	2
Electronic Circuits for I	Medical Applications (L1408)	Practical Course	1	1
Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical enginee	ring		
Educational Objectives	After taking part successfully, stud	ents have reached the	e following lear	ning results
Professional Competence				
Knowledge	 Students can explain the basic functionality of the information transfer by the central nervous system Students are able to explain the build-up of an action potential and it propagation along an axon Students can exemplify the communication between neurons and electron 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 implantiand artificial eyes 			
Skills	 Students can calculate the potential Students can give scenarios power signal acquisition. Students can develop the bleeman Students can define the built eye. 	s for further improve	ment of low-no	ise and lov
Personal Competence				
Social Competence	 Students are trained to solv teams together with experts Students are able to recogn for assistance to the right tir Students can document their results in a way that others of 	with different professize their specific limit ne. ir work in a clear mar	sional backgrou ations, so that nner and comm	nd. they can as unicate the
	 Students are able to realistic define actions for improvement Students can break down 	ents when necessary.		

Autonomy	 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			
	CompulsorBonus Form Description			
Course achievement	No None Subject theoretical and practical work			
	No 20 % Excercises			
Examination	Oral exam			
Examination duration and scale				
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory			

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

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

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

Module M1150): Continuum Mechanics			
Courses				
Title Continuum Mechanics Continuum Mechanics		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 3
Module	Prof. Christian Cyron	(Siliali)		
Responsible Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics a (forces and moments, stress, linear constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students h	nave reached	the following learr	ing results
Professional Competence				
Knowledge	The students can explain the fundame behavior of materials.	ntal concepts	s to calculate the	mechanical
Skills	The students can set up balance laws specific aspects, both in applied contexts			on theory to
Personal Competence Social Competence	The students are able to develop solutio form and to develop ideas further.	ns, to presen	t them to specialis	sts in written
Autonomy	The students are able to assess their independently and on their own ider continuum mechanics and acquire the k	ntify and sol	ve problems in	•
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 5	6	
Credit points				
Course achievement	None			
	Written exam			
Examination duration and scale				
Assignment for the Following	Computational Science and Engineer Elective Compulsory Materials Science: Specialisation Modelin Mechanical Engineering and Manage Compulsory Mechatronics: Technical Complementary Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation	ng: Elective Coement: Spec Course: Elective Course: Elect	ompulsory ialisation Materia tive Compulsory ns and Regeneration	lls: Elective ve Medicine: es: Elective

Curricula	Elective Compulsory			
	Biomedical Engineering: Specialisation Management and Business Administration:			
	Elective Compulsory			
	Product Development, Materials and Production: Core qualification: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective			
	Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory			

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

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

Module M1151	L: Material Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L15	35)	Lecture	2	3
Material Modeling (L15	36)	Recitation (small)	Section 2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continumechanics II and Continuum Mechanonlinear strain, free-body principle, energy)	nics (forces and	moments, stress	, linear and
Educational Objectives	After taking part successfully, studen	ts have reached t	the following learn	ing results
Professional Competence				
Knowledge	The students can explain the fundam laws	entals of multidir	nensional consitut	ive material
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
	The students are able to develop so	olutions, to prese	nt them to specia	alists and to
Social Competence	develop ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of materials modeling and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	 6	
Credit points		Eccure 5	-	
Course achievement				
Examination	Written exam			
Examination duration and scale				
the Following	Computational Science and Engine Elective Compulsory Materials Science: Specialisation Mod Mechanical Engineering and Man Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory	eling: Elective Co agement: Speci on Artificial Organ tion Implants a	ompulsory alisation Materia is and Regenerativ nd Endoprosthese	ls: Elective ve Medicine: es: Elective

Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective Compulsory

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

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

Module M1199	9: Advanced Functi	onal Material	S			
Courses						
				Hrs/wk 2	CP 6	
Admission Requirements	None	None				
Recommended Previous Knowledge		ls Science, e.g. Mat	erials Science I/	111		
Educational Objectives	After taking part successful	ly, students have re	ached the follo	wing learni	ng results	
Professional Competence						
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.					
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design 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						
Social Competence	The students are able to further.	present solutions	to specialists a	and to de	velop ideas	
Autonomy	 The students are able to assess their own strengths and weaknesses. gather new necessary expertise by their own. 					
Workload in Hours	Independent Study Time 15					
Credit points		72, Study Tille III Le	ecture 20			
Course achievement						
Examination	Presentation					
Examination duration and scale						
Assignment for the Following Curricula		and Management: pecialisation Artifician Specialisation Implospecialisation Medicapecialisation Management	Specialisation of Special Spec	egenerativ oprosthese and Cont siness Adr	e Medicine: es: Elective rol Theory: ninistration:	

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M127 Biology	9: MED II: Introduction t	o Biochemist	ry and M	olecular
Diology				
Courses				
Title		Typ	Hrs/wk	СР
	mistry and Molecular Biology (L0386)	Typ Lecture	2	3
Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	INODE			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, student	s have reached the	following learn	ing results
Professional				
Competence	<u> </u>			
Knowledge	 describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 			
Skills	 The students can recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 			
Personal				-
Competence	i e			
Social Competence	The students can participate in discus level.	ssions in research ai	nd medicine or	n a technical
	The students can develop understanding of topics from the course, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Tir	ne in Lecture 28		
Credit points	3			
Course achievement	INone			
Examination	Written exam			
Examination duration and scale	60 minutes			
	General Engineering Science (General Engineering, Focus Biometelectrical Engineering: Specialisation In General Engineering Science (Engineering, Focus Biomechanics: Corgeneral Engineering Science (Engineerial Engineering Science (Engineerial Engineering Science (Engineerial Engineering Science (Engineerial Engineering Science (Engineering Engineering E	mpulsory rman program): 5 man program, 7 man program, 7 chanics: Compulsory Medical Technology: glish program): 5 mpulsory	Specialisation semester): Specialisation semester): Specialisation	Biomedical pecialisation pecialisation bulsory Mechanical

Assignment for	Engineering: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation				
Curricula	Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation				
	Biomedical Engineering: Compulsory				
	Mechanical Engineering: Specialisation Biomechanics: Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration:				
	Elective Compulsory				
	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			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Hans-Jürgen Kreienkamp		
Language	DE		
Cycle	WiSe		
Content			
	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage		
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008		
Literature			

Module M1333	3: BIO I: Implants and Fr	acture Healing		
Courses				
Title Implants and Fracture	Healing (L0376)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to participate i "Implants and Fracture Healing".	n "Introduction into A	Anatomie" befor	e attending
Educational Objectives	After taking part successfully, stude	ents have reached the	following learn	ing results
Professional Competence				
Knowledge	The students can describe the diffe for their existence. The students can name different t given fracture morphologies.	•		
Skills	The students can determine the for static situations under specific assu		e human body ι	ınder quasi-
Personal Competence				
Social Competence	The students can, in groups, s calculation of internal forces.	olve basic numerica	l modeling tas	sks for the
Autonomy	The students can, in groups, s calculation of internal forces.	olve basic numerica	l modeling tas	sks for the
Workload in Hours	Independent Study Time 62, Study	Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination				
Examination duration and scale				
Assignment for the Following Curricula	General Engineering Science (General Engineering Science (Engineering: Compulsory General Engineering Science (Engineering, Focus Biomechanics: General Engineering Science (Engineering, Focus Biomechanics: General Engineering, Focus Biomechanical Engineering,	Compulsory German program): erman program, 7 nechanics: Compulsor erman program, 7 y English program): English program): Compulsory nglish program, 7 nechanics: Compulsor	Specialisation semester): Spry semester): Spr Specialisation Specialisation semester): Spry	pecialisation pecialisation Biomedical Mechanical pecialisation
536310	General Engineering Science (E Biomedical Engineering: Compulsor Mechanical Engineering: Specialisa Biomedical Engineering: Specialisa	ry zion Biomechanics: Co	mpulsory	

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

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

Module M1334	4: BIO II: Biomaterials
Courses	
Title Biomaterials (L0593)	Typ Hrs/wk CP Lecture 2 3
	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional	
Competence Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.
Personal Competence	
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Elective Compulsory

Course L0593: Biomaterials		
Тур	Lecture	
Hrs/wk	2	

Workload in Hours	3 Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language	EN		
Cycle			
	Topics to be covered include:		
	Introduction (Importance, nomenclature, relations)		
	2. Biological materials		
	2.1 Basics (components, testing methods)		
	2.2 Bone (composition, development, properties, influencing factors)		
	2.3 Cartilage (composition, development, structure, properties, influencing factors)		
	2.4 Fluids (blood, synovial fluid)		
	3 Biological structures		
	3.1 Menisci of the knee joint		
	3.2 Intervertebral discs		
	3.3 Teeth		
	3.4 Ligaments		
	3.5 Tendons		
Content	3.6 Skin		
	3.7 Nervs		
	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo) Acquisition of basics for theses work in the area of biomechanics.		
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.		
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.		
THERALUTE	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchil Livingstone, 1988.		
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Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berli Springer, 1996.	١,

Module M1342	2: Polymers					
Courses						
Title		Тур	Hrs/wk	СР		
	es of Polymers (L0389) with polymers (L1892)	Lecture Lecture	2 2	3 3		
Module		Lecture				
Responsible	Dr. Hans Wittich					
Admission Requirements	None					
Recommended Previous Knowledge	Basics: chemistry / physics / mate	erial science				
Educational Objectives	After taking part successfully, stu	dents have reached the	e following learn	ing results		
Professional						
Competence	Students can use the knowledge analysis.	of plastics and define	the necessary	testing and		
Knowledge	They can explain the complex rela	ationships structure-pro	perty relationsh	nip and		
	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).					
	Students are capable of					
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.					
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.					
Personal						
Competence	Students can					
		h				
	- arrive at funded work results in heterogenius groups and document them.					
Social Competence	- provide appropriate feedback and handle feedback on their own performance constructively.					
	Students are able to					
	- assess their own strengths and weaknesses.					
Autonomy	- assess their own state of learn steps on this basis.	ning in specific terms	and to define f	urther work		
	- assess possible consequences of their professional activity.					
Workload in Hours	Independent Study Time 124, Stu	dy Time in Lecture 56				
Credit points	6					
Course achievement	None					
Examination	Written exam					
Examination duration and						

scale	
Assignment for the Following Curricula	Compulsory

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

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

Module M0632	2: Regei	nerative	Medicine			
Courses						
Title Regenerative Medicine Lecture Tissue Enginee		nerative Med	icine (L1664)	Typ Seminar Seminar	Hrs/wk 2 2	CP 3 3
_	Prof. Ralf P					
Admission Requirements						
Recommended Previous Knowledge	None					
		g part succe	essfully, students	s have reached th	ne following learn	ing results
Professional Competence						
Knowledge	basic meth different m methods fo The stude	nods of regenethods of to the cultivents can over medicin	nerative medicir cissue engineerir ation of animal a putline the act	odule students of and to explain ag. They are able and human cells.	the use of the tise to give a basic of Tissue Engir	ssue cells for overview of neering and
	After succe	essful comp to use me	dical databases	lule students are for acquirierung	and presentatior	n of relevant
Skills	 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		ire able to w	ork together as	a team with 2-4 :	students to solve	given tasks
Social Competence	and discus	s their resul	lts in the plenary	and to defend the	nem.	
Autonomy		teams of a		rticipants will bo ons independentl		
Workload in Hours	Independe	nt Study Tir	ne 124, Study Ti	me in Lecture 56		
Credit points	6					
Course achievement	Compulso	_	Form Written elabor	Διι	escription sarbeitung zu Rii	ngvorlesung
acmevement	res	20 %	Written elabor		rotocol for lectur	
Examination	Presentation	on				

Examination duration and scale	Oral presentation + discussion (30 min)
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

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

Module M0548	8: Bioelectromagnetics:	Principles and	d Applicatio	ns
Courses				
Title Bioelectromagnetics: F	Principles and Applications (L0371) Principles and Applications (L0373)	Typ Lecture Recitation (small)	Hrs/wk 3 Section ₂	CP 5
Module Responsible	Prof. Christian Schuster	(Siliali)		
Admission Requirements	None			
	Basic principles of physics			
Educational Objectives	After taking part successfully, stud	ents have reached th	ne following learn	ing results
Professional Competence				
Knowledge	Students can explain the basic principles, relationships, and methods bioelectromagnetics, i.e. the quantification and application of electromagnetic field in biological tissue. They can define and exemplify the most important physic 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 medical technology.			
Skills	Students know how to apply va electromagnetic fields in biological make use of the elementary solu assess the most important effects they can order the effects c respectively, and they can analyz develop validation strategies for the effects of electromagnetic fields make an appropriate choice.	tissue. In order to outions of Maxwell's that these models orresponding to we them in a quantititheir predictions. The	do this they can r Equations. They predict for biolo vavelength and ative way. They ey are able to e	elate to and are able to gical tissue, frequency, are able to evaluate the
Personal Competence Social Competence	Students are able to work togethe are able to present their results			
Autonomy	Students are capable to gather publications and relate that inform to make a connection between the content of other lectures (e.g. the electrical engineering / physics). The field of bioelectromagnetics in English	ation to the context neir knowledge obta eory of electromagr ney can communicato	of the lecture. The ined in this lectunetic fields, fund	ney are able are with the amentals of
Workload in Hours	Independent Study Time 110, Stud	y Time in Lecture 70		

Credit points	6			
Course achievement	CompulsorBonus Yes 10 %	Form Presentation	Description	
		TTC3CITCACIOII		
Examination	Oral exam			
Examination duration and scale	45 min			
the Following	Electromagnetic Compa Electrical Engineering: International Managem Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Theoretical Mechanica Compulsory	atibility: Elective Co Specialisation Medient and Engineering: Specialisation Arg: Specialisation groups of Specialisation groups of Specialisation of the Engineering: Technology of Technology of Specialisation of the Engineering: Technology of the Engineering: Technology of the Engineering of the Engine		Engineering: ve Medicine: es: Elective trol Theory: ministration: se: Elective

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

Content Con	Course L0373: Bioe	electromagnetics: Principles and Applications				
Workload in Hours Independent Study Time 2, Study Time in Lecture 28 Lecturer Prof. Christian Schuster Language DE/EN Cycle SoSe Fundamental properties of electromagnetic fields (phenomena) - Mathematical description of electromagnetic fields (Maxwell's Equations) - Electromagnetic properties of biological tissue Principles of energy absorption in biological tissue, dosimetry - Numerical methods for the computation of electromagnetic fields (especially FDTD) - Measurement techniques for characterization of electromagnetic fields (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 very high frequency in biological tissue - Behavior of electromagnetic fields of very high frequency in biological tissue - Diagnostic applications of electromagnetic fields in medical technology - Therapeutic applications of electromagnetic fields in medical technology - The human body as a generator of electromagnetic fields - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", 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	Тур	Recitation Section (small)				
Lecturer Language DE/EN	Hrs/wk	2				
Lecturer Prof. Christian Schuster Language DE/EN Cycle SoSe - Fundamental properties of electromagnetic fields (phenomena) - Mathematical description of electromagnetic fields (Maxwell's Equations) - Electromagnetic properties of biological tissue - Principles of energy absorption in biological tissue, dosimetry - Numerical methods for the computation of electromagnetic fields (especially FDTD) - Measurement techniques for characterization of electromagnetic fields - Behavior of electromagnetic fields of low frequency in biological tissue - Behavior of electromagnetic fields of high frequency in biological tissue - Behavior of electromagnetic fields of high frequency in biological tissue - Behavior of electromagnetic fields of very high frequency in biological tissue - Diagnostic applications of electromagnetic fields in medical technology - Therapeutic applications of electromagnetic fields in medical technology - The human body as a generator of electromagnetic fields - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", 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	СР	1				
Cycle SoSe	Workload in Hours	Independent Study Time 2, Study Time in Lecture 28				
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 - 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) Literature - F. Barnes, B. Greenebaum, "Bioelectricity and Bioimpedance Basics", Academic Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of						
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Literature - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of		, , , , , , , , , , , , , , , , , , ,				
Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of						
	Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)				
		- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)				

Module M0630: Robotics and Navigation in Medicine						
-						
Courses						
Title Pohotics and Navigation	on in Medicine (10335)		Typ Lecture	Hrs/wk 2	CP 3	
Robotics and Navigation Robotics and Navigation			Project Seminar	2	2	
Robotics and Navigation	on in Medicine (L0336)		Recitation Section (small)	on 1	1	
Module Responsible	IPINI DIEVANNEI SCHIAE	efer				
Admission Requirements	None					
Recommended Previous Knowledge	 principles of pro 	ath (algebra, analys ogramming, e.g., in b skills				
Educational Objectives	After taking part succe	essfully, students h	ave reached the foll	owing learn	ing results	
Professional						
Competence	;	lain kinamatica an	d tracking systems	in clinical c	antavta ana	
Knowledge	The students can exp illustrate systems and respect to collision d typical systems regard	their components etection and saf	s in detail. Systems ety and regulations	can be eva	aluated with	
Skills	The students are abl systems for medical a		evaluate navigation	n systems	and robotic	
Personal Competence						
Social Competence	The students discuss incoorporate feedback		r groups, provide he	lpful feedb	ack and car	
Autonomy	The students can reflection. They can present the i			e results o	f their work	
Workload in Hours	Independent Study Tir	ne 110, Study Time	e in Lecture 70			
Credit points	6					
Course achievement	CompulsorBonus Yes 10 % Yes 10 %	Form Written elaborati Presentation	Descrip on	tion		
Examination	Written exam					
Examination duration and scale	90 minutes					
	Computer Science: Sp. Electrical Engineering: Computational Science Robotics: Elective ComInternational Manager Elective Compulsory Mechatronics: Speciali Biomedical Engineerin Elective Compulsory Biomedical Engineeri	Specialisation Medice and Engineering inpulsory ment and Engineering sation Intelligent Station A	dical Technology: Elegical Technology: Elegical Systems and Robotics rtificial Organs and	ective Comp stems Engi . Electrical I s: Elective C Regenerativ	oulsory neering and Engineering Compulsory ve Medicine:	

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

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

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

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

Module M0634	4: Introduction i	nto Medical	Technology an	d Syst	ems
Courses					
Courses			_	, .	
	cal Technology and Systen cal Technology and Systen		Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Introduction into Medic	cal Technology and Systen	ns (L1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaef	er			
Admission Requirements	None				
Recommended Previous Knowledge	principles of stochastic	S	ulus)		
Educational Objectives	After taking part succes	ssfully, students ha	ave reached the follow	wing learn	ing results
Professional Competence					
Knowledge	The students can exp systems, computer aid to give an overview of i	ed surgery, and m	nedical information sy	stems. Th	ey are able
Skills	The students are able clinical applications.	to evaluate syste	ms and medical dev	ices in the	e context of
Personal Competence					
Social Competence	The students describe tasks that are solved in		dical technology as	a project,	and define
Autonomy	The students can refle They can present the re			results of	their work.
Workload in Hours	Independent Study Tim	e 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 % Yes 10 %	Form Written elaboration	Descript ion	ion	
Examination	Written exam				
Examination duration and scale					
Assignment for the Following	General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computer Science: Sp Compulsory Electrical Engineering: General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computational Science Elective Compulsory	ry Science (Germany: Compulsory Decialisation Compulsory Core qualification: Science (Englistry Science (Englishy: Compulsory	outer and Software Elective Compulsory h program): Speci	ester): Spendineering ialisation ester): Spendine	pecialisation ng: Elective Biomedical pecialisation
	-				

Curricula	Computational Science and Engineering: Specialisation Computer Science: Elective
	Compulsory
	Computational Science and Engineering: Specialisation Mathematics & Engineering
	Science: 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
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

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

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

Module M0752	2: Nonlinear Dynamics							
Courses								
Title Nonlinear Dynamics (L	.0702)	Typ Integrated Lecture	Hrs/wk 4	CP 6				
Module Responsible	Prof. Norbert Hoffmann							
Admission Requirements	None							
Recommended Previous Knowledge	Linear Algebra							
Educational Objectives	LATTEL TAKING NALL SUCCESSIUM STUGENTS	have reached the follo	owing learn	ing results				
Professional Competence								
Knowledge	to develop and research new terms and	d concepts.						
Skills	Dynamics and to develop novel method	Students are able to apply existing methods and procesures of Nonlinea Dynamics and to develop novel methods and procedures.						
Personal Competence Social Competence Autonomy	Students can reach working results also	esearch tasks individua	ally and to	identify and				
Workload in Hours	Independent Study Time 124, Study Tir							
Credit points								
Course achievement	INANA							
Examination	Written exam							
Examination duration and scale	2 Hours							
Assignment for the Following Curricula	Piemodical Engineering Chesialisation	ering: Specialisation ering: Specialisation II. ment: Specialisation esign: Elective Compul Systems and Robotics Artificial Organs and Fon Implants and End on Implants and End on Medical Technology on Management and Bu d Production: Core Technical Complement	Scientific Mechatron Mechatroni sory Elective Callegeneration doprosthese and Continusiness Adir qualification etary Cours	Computing: ics: Elective cs: Elective Compulsory ve Medicine: es: Elective and Theory: ministration: on: Elective se: Elective				

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

Courses Title Semiconductor Technol Semiconductor Technol Module	logy (L0722)	T						
	ogy (L0723)	Typ Lecture Practical Course	Hrs/wk 4 2	CP 4 2				
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, stud	ents have reached the fol	llowing learn	ing results				
Professional Competence								
Knowledge	 Students are able to describe and to explain current fabrication techniques for Si and GaAs substrates, to discuss in details the relevant fabrication processes, process flows and the impact thereof on the fabrication of semiconductor devices and integrated circuits and to present integrated process flows. 							
Skills	 Students are capable to analyze the impact of proce to select and to evaluate proce to develop process flows for the 	esses and	_					
Personal Competence								
	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.							
Autonomy	None							
Norkload in Hours	Independent Study Time 96, Study	Time in Lecture 84						
Credit points	6							
Course achievement	None							
Examination	Oral exam							

duration and scale	
Assignment for the Following Curricula	Compulsory Riomodical Engineering: Specialisation Modical Technology and Control Theory:

	Liective Compuisory								
Course L0722: Semiconductor Technology									
	Lecture								
Hrs/wk									
СР									
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56								
Lecturer	Prof. Hoc Khiem Trieu								
Language	DE/EN								
Cycle	SoSe								
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray lithography and phase shift lithography, electron beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wetchemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching backsputtering, ion m								
	 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)
	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
Literature	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner VerlagH. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	 K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M083!	5։ Hւ	ımano	id Rob	otics					
Courses									
Title Humanoid Robotics (LO	0663)					Typ Seminar		Hrs/wk 2	CP 2
Module Responsible			h						
Admission Requirements	None								
Recommended Previous Knowledge	•		ction to co theory and						
Educational Objectives	After	taking pa	art success	sfully, st	tudents h	ave reached	the follo	wing learn	ing results
Professional Competence									
Knowledge						bots. rol concepts	for differ	ent tasks	in humanoid
Skills		based of Student	n specified s generali	d literatı ze deve	ure loped res	ut selected a ults and pres give a presen	sent then		
Personal Competence									
Social Competence		present They a	them	o provic	de appro	ng solutions priate feedb			
Autonomy		present Student	ation for s s familiari ow preser	pecific t ze them	tasks and nselves w	and drawb select the be ith a scientifi students, su	est soluti ic field, a	on re able of	introduce it
Workload in Hours	!	endent S	tudy Time	32, Stu	ıdy Time	in Lecture 28	3		
Course									
Course achievement Examination	!								
Examination duration and scale	30 mi								
	Comp Mecha Mecha Biome	oulsory atronics: atronics:	Specialisa Specialisa gineering:	ition Inte	elligent S stem Desi	Control an ystems and F ign: Elective rtificial Orgar	Robotics: Compuls	Elective (Compulsory

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

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

Courses					
Title Linear and Nonlinear S	System Identification (L0660)	Typ Lecture	Hrs/wk 2	CP 3	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
Recommended Previous Knowledge	Classical control (frequenState space methodsDiscrete-time systems	alue decomposition			
Educational Objectives	I After taking nart cliccectilly ct	cudents have reached the	e following learn	ing results	
Professional Competence					
Knowledge	 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 Kalmar realisation theory 				
Skills	 Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model They are capable of applying subspace algorithms to the experimenta identification of linear models for dynamic systems They can do the above using standard software tools (including the Matlat System Identification Toolbox) 				
Personal Competence					
Social Competence	Students can work in mixed gro	ups on specific problems	to arrive at join	t solutions.	
Autonomy		Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.			
Workload in Hours	Independent Study Time 62, Stu	ıdy Time in Lecture 28			
Credit points					
Course achievement	INONE				
Examination	Oral exam				
Examination duration and scale	30 min				
	Electrical Engineering: Special Compulsory Mechatronics: Specialisation Into	alisation Control and elligent Systems and Rob	_		

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

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

Courses											
Title Optimal and Robust Co	ontrol (I	L0658)					p ture citation	Soction	Hrs/wk	CP 3	
Optimal and Robust Co	ontrol (I	L0659)					nall)	Section	2	3	
Module Responsible		Herbert \	Werner								
Admission Requirements	None										
Recommended Previous Knowledge	•	Classica State sp Linear a	pace me	thods				us)			
Educational Objectives	After	taking pa	art succe	essfully	, stude	nts have	reached	d the foll	owing lear	ning resi	ults
Professional Competence											
Knowledge	•	solution They ca state es They ca stability They ca case of They ca lends its They ca can gua They un	n of LQ pan explantion	problement the n. ain how in how lesign pain how obust controller to the controller	the Hones on the Hones corporate with the Hones corporate with the Hones controlled to the Hones contr	betwee 2 and h straints. 6 design 1 uncerta r design on the serforman is and s	n optim I-infinity probler ainty cal small ga sce for a ynthesis	nal state norms m can be n be rep nin theor n uncert s conditi	feedback are used e formulateresented if em - a robustions on fee	and opto to represed as spondant n a way	timese eci th
Skills	•	multiva They ar form of it. They ar control carrying They ar system, They ar matrix i They ca	riable pl re capab e capab loops in g out a n re capab , and of re capab inequalit	lant moble of interpretation of the company of the	odels. represe plant, a ranslatir nstraint sensitivi construct ing a m formula fil), and ll of the	nting a land of using time as on closty designating an language ing analof using	H2 or H sing stan and freq osed-loo n. LFT unc ective ro ysis and standar	I-infinity ndard so uency de p sensit ertainty bust cor d synthe d LMI-so	LQG co design profitware too omain spec- civity funct model for ntroller. sis conditi lvers for so software	oblem ir ls for so cifications, ar an unce ons as liblying the	n th lvir ns fo nd erta ine em
Personal Competence											
Social Competence				_	-	-	-		-		
Autonomy									provided (le problems.		ote

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	
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory 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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

ourses				
itle larketing of Innovation BL Marketing of Innov		Typ Lecture Project-/problem-	Hrs/wk 4 1	CP 4
		based Learning		
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous Knowledge	 Module International Busine Basic understanding of bus decision theory, project ma Bachelor-level Marketing Competitor Strategies, Basi Unerstanding the difference Understanding of the impomarkets Good English proficiency; p 	iness administration princi nagement, international b Knowledge (Marketing In ics of Buying Behavior) es beweetn B2B and B2C n rtance of managing innove	usiness) struments, narketing	Market ar
Educational Objectives	After taking part successfully, stud	dents have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	 Specific characteristics in the Approaches for analyzing the development The gathering of information Concepts and approaches product and service develor Approaches and tools for each of new products and innovation Marketing mix elements requirements and challenged Pricing methods for new products and innovation Pricing methods for new products and complete Communication concepts and concepts are specified and concepts are specif	he marketing of innovative he current market situation about future customer not to integrate lead users pment processes ensuring customer-oriental ative services that take into consess of innovative products a oducts and services x sales forces and persona	n and the fureeds and restand their cion in the dideration to the selling	ture mark quirements needs in evelopmer he specif
Skills	 Design and to evaluate strategies Analyze markets by applyir Conduct forecasts and dev planning Translate customer needs and successfully apply adviservice development Use adequate methods to f services Choose suitable pricing innovations Make strategic sales decisions 	decisions regarding management of the decisions regarding management of the decisions and technology relop compelling scenarios into concepts, prototypes anced methods for custom foster efficient diffusion of strategies and communications.	portfolios as a basis and marke ner-oriented innovative p	for strateg table offer product ar roducts ar ctivities fo

Competence	
	The students will be able to
Social Competence	 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
	The students will be able to • Acquire knowledge independently in the specific context and to map this
Autonomy	 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	
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective 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: Mar	keting of Innovations
Тур	Lecture
Hrs/wk	
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
	 Introduction Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	 objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
Content	 Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	 Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	 Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	• Diffusion of Innovations, Communication Objectives, Communication Instruments
	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
Literature	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press
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Course L0862: PBL	Marketing of Innovations
Тур	Project-/problem-based Learning
Hrs/wk	1
СР	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1) forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation, managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making within a market simulation game.
Literature	

Module M1143	3: Mechanical Design Metho	dology		
Courses				
Title Mechanical Design Me Mechanical Design Me		Typ Lecture Recitation (small)	Hrs/wk 3 Section 1	CP 4 2
Module Responsible	Prof. Josef Schlattmann	(Smail)		
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached t	he following learn	ing results
Professional Competence				mlinakina of
Knowledge	Science-based working on product de specific product design techniques	esign consider	ing targeted ap	plication of
Skills	Creative handling of processes used for complex product design problems / techniques following theoretical aspects.	Application	eparation and for of various proc	mulation of luct design
Personal Competence				
Social Competence				
Autonomy		- !		
Credit points	Independent Study Time 124, Study Tim	e in Lecture 50)	
Course				
achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	I Droduct Dovolonment Materials a	sign: Elective Contificial Organs Implants ar Medical Tech Management and Production oduction: Specialisation	compulsory is and Regenerative and Endoprosthese anology and Conte and Business Adr on: Specialisation ialisation Producti cialisation Materia Product Develo	re Medicine: es: Elective rol Theory: ministration: on Product on: Elective als: Elective pment and

Compulsory

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

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

Module M0938: Bioprocess Engineering - Fundamentals				
Courses				
Title	g - Fundamentals (L0841)	Typ Lecture	Hrs/wk	CP 3
_	g- Fundamentals (L0842)	Recitation Section	_	1
	g - Fundamental Practical Course (L0843)	(large) Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", mod	ule "fundamentals for _l	process er	ngineering"
Educational Objectives	After taking part successfully, students	have reached the follow	wing learn	ing results
Professional Competence				
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
Skills	After successful completion of this mode describe different kinetic approach calculate the corresponding para predict qualitatively the influence redox equivalents and growth informalized bioprocesses on basis metabolic flux equations distinguish between scale-up bioprocesses (anaerobic, aerobic as well as to apply them to curred propose solutions to complicate the corresponding models to explore new knowledge resour identify scientific problems with solutions. to document and discuss their proposes.	ches for growth and sumeters nce of energy general nibition on the fermental of stoichiometry and criteria for differe as well as microaero nt biotechnical problem d biotechnological pro	bstrate-up tion, rege ation proce d to set ent biore bic) to con blems and ewly gaine use and t	eneration of ess up / solve actors and mpare them d to deduce ed contents o formulate
Personal Competence Social Competence	After completion of this module partic questions in small teams to enhance opinions and increase their capacity environments.	the ability to take	position to	o their ow
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84			

Credit points	6
Course achievement	Cubiast theoretical and
Examination	Written exam
Examination duration and scale	90 min
	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

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

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

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

Module M1280	0: MED II: Introduction to Physiology
Courses	
Title Introduction to Physiol	Typ Hrs/wk CP logy (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	
Knowledge	 describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.
Skills	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	
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	INONE
Examination	Written exam
Examination duration and scale	60 minutes
scale	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation General Engineering Science (German program, 7 semester): Specialisation
	Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical
Assianment for	Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory
the Following	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation

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

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

Module M1277	7: MED I: Introduction to Anatomy	
Courses		
Title Introduction to Anatom	Typ Hrs/wk CP my (L0384) Lecture 2 3	
Module Responsible	Prof. Udo Schumacher	
Admission Requirements	INONA	
Recommended Previous Knowledge	None None	
Educational Objectives	After taking part successfully, students have reached the following learning re-	sults
Professional Competence		
Knowledge	The students can describe basal structures and functions of internal organs are musculoskeletal system. The students can describe the basic macroscopy and microscopy of those syst	
Skills	The students can recognize the relationship between given anatomical facts and development of some common diseases; they can explain the relevan structures and their functions in the context of widespread diseases.	
Personal Competence		
_	The students can participate in current discussions in biomedical research medicine on a professional level.	h and
Autonomy	The students are able to access anatomical knowledge by themselves participate in conversations on the topic and acquire the relevant know themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	3	
Course achievement		
	Written exam	
Examination duration and scale	90 minutes	
	General Engineering Science (German program): Specialisation Mech Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biom Engineering: Compulsory	iedical
the Following	General Engineering Science (German program, 7 semester): Specialis Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialis Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanicering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialis Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialis Biomedical Engineering: Compulsory	sation / nanical nedical

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				
Тур	Lecture			
Hrs/wk	2			
СР	3	3		
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28		
Lecturer	Prof. Tobias Lange			
Language				
Cycle				
	General Anatomy	1		
	1 st week:	The Eucaryote Cell		
	and .			
	2 nd week:	The Tissues		
	3 rd week:	Cell Cycle, Basics in Development		
	4 th week:	Musculoskeletal System		
		Musculoskeletai System		
	5 th week:	Cardiovascular System		
	6 th week:	Respiratory System		
	7 th week:	Genito-urinary System		
Content	8 th week:	Immune system		
	9 th week:	Digestive System I		
	10 th week:	Digestive System II		
	11 th week:	Endocrine System		
	12 th week:	Nervous System		
	13 th week:	Exam		
Literature	Adolf Faller/Michae Stuttgart, 2012	l Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag		
1				

Module M1332	2: BIO I: Experimental Met	hods in Biom	nechanics	
Courses				
Title Experimental Methods	in Biomechanics (L0377)	Typ Lecture	Hrs/wk CP 2 3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	LNONA			
	It is recommended to participate attending "Experimentelle Methoden".		nd Frakturheilung" before	
Educational Objectives		s have reached the	e following learning results	
Professional Competence				
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under given fracture morphologies.			
	The students can describe different measurement techniques for forces and movements, and choose the adequate technique for a given task. The students can describe the basic handling of several experimental techniques			
Skills	used in biomechanics.			
Personal Competence				
Social Competence	The students can, in groups, solve bas The students can, in groups, solve bas	•		
Autonomy	Independent Study Time 62, Study Tir		5N5.	
Credit points		ne in Lecture 26		
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
	General Engineering Science (General Engineering, Focus Biomed General Engineering Science (General Engineering: Compulsory General Engineering Science (Engineering: Compulsory	mpulsory rman program): man program, 7 chanics: Compulso man program, 7	Specialisation Biomedica semester): Specialisation ry semester): Specialisation	
the Following	General Engineering Science (Engineering, Focus Biomechanics: Cor General Engineering Science (Eng Mechanical Engineering, Focus Biomed General Engineering Science (Eng Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation	npulsory lish program, 7 chanics: Compulso lish program, 7	semester): Specialisation ry semester): Specialisation	

	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
В	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective
C	Compulsory
В	Biomedical Engineering: Specialisation Medical Technology and Control Theory:
E	Elective Compulsory
В	Biomedical Engineering: Specialisation Management and Business Administration:
E	Elective Compulsory
T	Fechnomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M127 Therapy	8: MED I: Introduction	to Radiology	and R	adiation
Courses				
Title Introduction to Radiolo	ogy and Radiation Therapy (L0383)	Typ Lecture	Hrs/wk 2	CP 3
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students	have reached the fol	lowing learr	ning results
Professional Competence				
Knowledge	Therapy The students can distinguish different types of currently used equipment w respect to its use in radiation therapy. The students can explain treatment plans used in radiation therapy interdisciplinary contexts (e.g. surgery, internal medicine). The students can describe the patients' passage from their init admittance through to follow-up care. Diagnostics The students can illustrate the technical base concepts of projection radiograph including angiography and mammography, as well as sectional imaging technique (CT, MRT, US). The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques. The students can choose the right treatment method depending on the patient clinical history and needs. The student can explain the influence of technical errors on the imaging techniques.			
Skills	The student can draw the right corfindings or the error protocol. Therapy The students can distinguish curative they came to that conclusion. The students can develop adequate the biological aspects. The students can use the therapeutic purpose The students can distinguish different depending on the situation (location of that situation (irradiation planning). The student can assess what an indiceted (e.g. follow-up treatment, sports, so services, psycho-oncology). Diagnostics	and palliative situat herapy concepts and r principle (effects vs ad kinds of radiation, ca the tumor) and choos vidual psychosocial s	cions and mand relate it to the deciration of the energes service shows	notivate why the radiation ts) the best one gy needed in

	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.
Personal Competence	
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.
	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	NNDD
Examination	Written exam
Examination duration and scale	
the Following	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering: Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine:

Course L0383: Introduction to Radiology and Radiation Therapy		
Тур	Lecture	
Hrs/wk	2	
СР	3	

1	DE			
Language Cycle				
-	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments			
Literature	 "Technik der medizinischen Radiologie" von T. + Laubenberg - 7. Auflage – Deutscher Ärzteverlag – erschienen 1999 "Klinische Strahlenbiologie" von Th. Herrmann, M. Bauman 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	5: BIO II: Artificial Joint	Replacement		
Courses				
Title Artificial Joint Replacer	ment (L1306)	Typ Lecture	Hrs/wk 2	CP 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic ar	nd surgical techniques is	recommended	
Educational Objectives	After taking part successfully, stu	dents have reached the	following learn	ing results
Professional Competence				
Knowledge				
Skills	The students can explain the advantages and disadvantages of different kinds of endoprotheses.			
Personal Competence				
Social Competence	The students are able to discuss and the teachers.	issues related to endopi	rothese with stu	udent mates
Autonomy	The students are able to acquire information with respect to its cre		n. They can als	so judge the
Workload in Hours	Independent Study Time 62, Stud	ly Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Blomedical Engineering: Specialisation Medical lechnology and Control Theory:			

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

Module M0845	5: Feedback Control in I	Medical Technol	logy	
Courses				
Title Feedback Control in Me	edical Technology (L0664)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Jonannes Kreuzer			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Control, Basics in Physiol	ogy		
Educational Objectives	After taking part successfully, stud	dents have reached the	following learn	ing results
Professional Competence				
	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.			
Knowledge	Internal control loops of the huma design of external closed loop sys			
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.			
Skills	Application of modeling, identific technology.	ation, control technolo	ogy in the field	l of medical
Personal Competence				
Social Competence	Students can develop solutions t their results (e.g. during project w	o specific problems in eek)	small groups	and present
Autonomy	Students are able to find necessal lecture. They are able to continuo of their learning process. They comma consistent whole.	usly evaluate their kno	wledge and to	take control
Workload in Hours	Independent Study Time 62, Study	y Time in Lecture 28		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following Curricula	Biomedical Engineering: Specialis	sation Control and isation Implants and ation Artificial Organs a	Power System Endoprosthese and Regenerative	ns: Elective es: Elective ve Medicine:

Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory

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

Courses				
Courses				
Title Advanced Topics in Co	ontrol (L0661)	Typ Lecture	Hrs/wk 2	CP 3
Advanced Topics in Co		Recitation	Section 2	3
Advanced Topics in Co	ontrol (L0602)	(small)	<u> </u>	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	INODE			
Recommended	H-infinity optimal control, mixed-ser	nsitivity design, line	ar matrix inequal	ities
Educational Objectives		nts have reached th	ne following learr	ing results
Professional Competence				
Knowledge	 Students can explain the advischeduling approach They can explain the represent LPV systems They can explain how stability can be formulated as LMI contour they can explain how gridding synthesis problems for LPV systems They are familiar with polytons some of the basic synthesis the structures Students can explain how grade communication topology of more they can explain the converted protocols They can explain analysis and involving either LTI or LPV agains Students can explain the stability of the stab	ntation of nonlinear ty and performance ditions ag techniques can be extens pic and LFT represe techniques associate aph theoretic conce nultiagent systems ergence properties d synthesis condition ent models ate space represe discretized accordin the extension of	e conditions for I see used to solve a entations of LPV seed with each of pts are used to re so of first order ns for formation of the bounded rea	orm of quasion of quas
	 Students are capable of corcarry out a mixed-sensitivity do this using polytopic, LFT or They are able to use standar for these tasks 	design of gain-sch r general LPV mode	neduled controlle ls	rs; they ca

	 Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

Specialization Artificial Organs and Regenerative Medicine

Courses					
			T	Ilaa (aala	CD
Title Intelligent Systems in	Medicine (L0331)		Typ Lecture	Hrs/wk 2	CP 3
Intelligent Systems in			Project Seminar	2	2
Intelligent Systems in	Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlae	fer			
Admission Requirements	INIONA				
Recommended Previous Knowledge	 principles of store 	gramming, Java/C-			
Educational Objectives	TALLEL TAKING DALL SILCE	ssfully, students h	ave reached the follo	wing learn	ing results
Professional					
Competence	;	to analyza and cal	vo clinical trantmant	ماممام د	and decision
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.				
Personal Competence					
Social Competence		The students discuss the results of other groups, provide helpful feedback and car incoorporate feedback into their work.			
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tim	ne 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	1 Yac 10 %	Form Written elaborati Presentation	Descript on	ion	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Spe Electrical Engineering: Computational Science	Specialisation Med	lical Technology: Elec	tive Comp	ulsory

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

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

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

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

Module M0629	9: Intelligent Autonomous Agents and Cognitive Rob	otics		
Courses				
_	us Agents and Cognitive Robotics (L0341) Lecture Recitation (small) Typ Hrs/wk CP Lecture 2 4 Recitation (small)			
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous Knowledge	Vectors, matrices, Calculus			
Educational Objectives	I ATTOR TAKING NART CHCCOCCIUIIV CTHOONIC NAVO ROACNOG THO TOHOWING IDARNING RO	esults		
Professional Competence				
Knowledge	Students can explain the agent abstraction, define intelligence in terms of r behavior, and give details about agent design (goals, utilities, environments) can describe the main features of environments. The notion of adversarial cooperation can be discussed in terms of decision problems and algorith solving these problems. For dealing with uncertainty in real-world sce students can summarize how Bayesian networks can be employed as a known representation and reasoning formalism in static and dynamic settings. In act students can define decision making procedures in simple and sequential see with and with complete access to the state of the environment. In this constitutes can describe techniques for solving (partially observable) Markov deproblems, and they can recall techniques for measuring the value of inform Students can identify techniques for simultaneous localization and mappin can explain planning techniques for achieving desired states. Students can coordination problems and decision making in a multi-agent setting in the different types of equilibria, social choice functions, voting protocol, and mechaesign techniques.). They I agent ms for Inarios		
Skills	Students can select an appropriate agent architecture for concrete agent app scenarios. For simplified agent application students can derive decision treapply basic optimization techniques. For those applications they can also Bayesian networks/dynamic Bayesian networks and apply bayesian reason simple queries. Students can also name and apply different sampling techniq simplified agent scenarios. For simple and complex decision making studer compute the best action or policies for concrete settings. In multi-agent situ students will apply techniques for finding different equilibria states,e.g., equilibria. For multi-agent decision making students will apply different protocols and compare and explain the results.	es and create ing foues found foues foue foues foue foues foues foues foues foue foue foues foue foue foues foue foue foue foue foue foue foue foue		
Personal Competence				
Social Competence	Students are able to discuss their solutions to problems with others. communicate in English	. They		
Autonomy	Students are able of checking their understanding of complex concepts by solving varaints 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	Blomodical Enginooring: Spocialication Implants and Endoprocthocos: Eloctivol

Course L0341: Inte	lligent Autonomous Agents and Cognitive Robotics		
Тур	Lecture		
Hrs/wk	2		
СР	4		
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28		
Lecturer	Rainer Marrone		
Language	EN		
Cycle	WiSe		
Content	 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 join probability distribution, marginalization, summing out, answering queries complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning 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		
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Pete Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009 		

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

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

Courses				
Title		Тур	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
Introduction to Waveg Compatibility (L1877)	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
	ulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in	Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Er	ngineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00	01)	Lecture	2	4
Ceramics Technology	(L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended				
Previous				
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
	Depends on choice of courses			
Credit points				
Assignment for the Following Curricula	Riomodical Engineering: Specialisation Medical Technology and Control Theory:			

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Lecture	
Hrs/wk	3	
СР	4	
	Independent Study Time 78, Study Time in Lecture 42	
Examination Form		
Examination duration and scale		
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques	
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007) 	

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

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

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

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

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

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

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

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical N	•	Seminar	2	3
Introduction to Wavego Compatibility (L1669)	uides, Antennas, and Electromagnetic	Lecture	3	4
Introduction to Waveg Compatibility (L1877)	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
	ulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in	Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Er	ngineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00	01)	Lecture	2	4
Ceramics Technology	L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following Curricula	owing Elective Compulsory Riamodical Engineering: Specialisation Management and Rusiness Administration:			

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
	Lecture	
Hrs/wk		
СР		
	Independent Study Time 78, Study Time in Lecture 42	
Examination Form		
Examination duration and		
scale		
	Prof. Christian Schuster	
Language		
Cycle		
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques	
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) 	
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)	

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

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

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

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

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

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

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

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

Module M0746	6: Microsystem	Engineering			
Courses					
Title Microsystem Engineering (L0680) Microsystem Engineering (L0682)			Typ Lecture Project-/problem-	Hrs/wk 2 2	CP 4
	based Learning				
	Prof. Manfred Kasper				
Admission Requirements	LNIONE				
Recommended Previous Knowledge	Basic courses in physi	ics, mathematics a	nd electric enginee	ring	
Educational Objectives	LATTER TAKING NART SHEET	essfully, students h	nave reached the fo	llowing learn	ing results
Professional Competence					
Knowledge	The students know ab well as their application	out the most impo ons in sensors and	rtant technologies a actuators.	and materials	s of MEMS
Skills		Students are able to analyze and describe the functional behaviour of MEN components and to evaluate the potential of microsystems.			
Personal Competence		salva spacific proble	lows along as in a	aroup and to	procent th
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.				
Autonomy	Students are able to a integrate and associal			ecialized liter	ature and
	Independent Study Tir	me 124, Study Tim	e in Lecture 56		
Credit points	<u> </u>				
Course achievement	CompulsorBonus No 10 %	Form Presentation	Descri	ption	
Examination	Written exam				
Examination duration and scale	2h				
	Electrical Engineering: Core qualification: Compulsory Computational Science and Engineering: Specialisation Systems Engineering ar Robotics: 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: Specialisation System Design: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine				
Assignment for the Following Curricula	Elective Compulsory	ing: Specialisation	n Implants and E	ndoprostheso	es: Electives:

Elective Compulsory
Microelectronics and Microsystems: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
Flective Compulsory

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

Course L0682: Micr	Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Manfred Kasper		
Language	EN		
Cycle	WiSe		
	Examples of MEMS components		
	Layout consideration		
Content	Electric, thermal and mechanical behaviour		
	Design aspects		
Literature	Wird in der Veranstaltung bekannt gegeben		

Module M075	L: Vibration Theory
Courses	
Title Vibration Theory (L070)	Typ Hrs/wk CP Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	tnem furtner.
	Students are able to denote methods of Vibration Theory and develop them further.
Personal Competence	
-	Students can reach working results also in groups.
· ·	Students are able to approach individually research tasks in Vibration Theory.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	2 Hours
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: 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: Technical Complementary Course: Elective Compulsory

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

Courses						
Title			Тур	Hrs/wk	СР	
Microsystems Technology (L0724)			Lecture	2	4	
Microsystems Technolo	ogy (L0725)		Project-/problem- based Learning	2	2	
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous Knowledge	Dacies in physics, shor	nistry, mechan	ics and semiconducto	r technology		
Educational Objectives	I ATTER TAKING NART SLICCE	essfully, studen	ts have reached the f	ollowing lear	ning result	
Professional						
Competence	Students are able					
	 to present and to explain current fabrication techniques for microstructures especially methods for the fabrication of microsensors and microactuators, as as the integration thereof in more complex systems 					
Knowledge	 to explain in detail 	ails operation	principles of microse	nsors and m	icroactuato	
	to discuss the pote	ential and limit	ation of microsystems	in applicatio	n.	
	Students are capable					
	to analyze the fea.	sibility of micro	systems,			
	to develop process	s flows for the	fabrication of microstr	uctures and		
Skills	• to apply them.					
Personal Competence						
Social Competence	Students are able to well as to present and				eam work	
Autonomy	None					
	Independent Study Tin	ne 124, Study	Fime in Lecture 56			
Credit points						
	Compulsor B onus	Form	Studie	ription erenden f ruppen	ühren e	

Course achievement	Yes	NIANA	Subject oractical v		al and	Laborpra Gruppe diskutiert Ergebniis vor dem	präse die The e ihrer	entiert eorie sow Labortäti	
Examination	Oral exam								
Examination duration and scale									
Assignment for the Following Curricula	Electrical Er Computatio Robotics: El Internationa Compulsory Biomedical Elective Cor Biomedical Compulsory Biomedical Elective Cor Biomedical Elective Cor	Engineering: mpulsory Engineering: Engineering: mpulsory Engineering:	npulsory pecialisat and Engi ulsory nt and En Specialis Speciali Speciali	neering: Sogineering ation Artif disation In sation Me sation Ma	al Techno Specialis : Special ficial Org mplants edical Te	ation Systation II. ans and R and End echnology nt and Bu	Mechat Mechat egeneral oprosth and C	ngineerin ronics: El ative Med eses: El ontrol Tr Administr	g and ective licine: ective neory:

Course L0724: Mici	rosystems Technology
Тур	Lecture
Hrs/wk	
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
	 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; therma 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 senson and magneto-transistor; magnetoresistive sensors: magneto resistance, AMF

Content

- 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)

M. Madou: Fundamentals of Microfabrication, CRC Press, 2002

Literature

N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009

T. M. Adams, R. A. Layton: Introductory MEMS, Springer, 2010

G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

Module M0814	4: Technology Managem	ent		
Courses				
Courses Title		Тур	Hrs/wk	СР
Technology Manageme	ent (L0849)	Project-/problem-	3	3
Technology Managemo		based Learning Project-/problem-	2	3
	<u> </u>	based Learning		
Module Responsible				
Admission Requirements				
Recommended Previous	I Pachalar knowladgo in business ma	nagement		
Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	 Technology Intelligence Technology Portfolio Manage Technology Portfolio Monage Technology Portfolio Monage IP Management Organizing Technology Deve Technology Organization Technology Funding & 	and Lifecycle Manageme te and Planning ment Methodology n and Exploitation lopment ion & Management	ent (I/II)	
Skills	 Develop an understanding of a national as well as internat Equip students with an understanding of a national as well as internat Equip students with an understanding of Management (strategic, of aspects) Foster a strategic oriental process as well as Technologistrategy Clarify activities of Technologistrategy Clarify activities of Technologistrate and exploitatio Strengthen essential communate and R&D-management (strength of the process) Basic concepts, models at technology, R&D and innovation as a process (stepper strength of the process (stepper s	ional level erstanding of important of perational, organization ution to problem-solving by Management and its in logy Management (e.g. n) nunication skills and a and financial issues comment. Further topics to be and tools, relevant to tion	elements of al and pro within the apportance for technolog basic under the procession of the discussed and the procession of the discussed and the discussion and the discussed and the discussion and the discussed and the discussion and the	Technolog cess-relate innovation or corporate y sourcing estanding of fechnology-dinclude:
Personal Competence				
Social Competence	Interact within a teamRaise awareness for globabl	issues		
Autonomy	Gain access to knowledge soInterpret complicated cases	urces		

	Develop presentation skills		
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		
_	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

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

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

Courses				
-	ry and Design (L0656) ry and Design (L0657)	Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 4 2
Module Responsible		(Siliali)		
Admission Requirements	None			
Recommended	Introduction to Control Systems			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 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 			
Skills	 Students can transform transfer function models into state space models a vice versa They can assess controllability and observability and construct minin realisations They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discretime domain, and decide which is appropriate for a given sampling rate They can identify transfer function models and state space models dynamic systems from experimental data They can carry out all these tasks using standard software tools (Matl Control Toolbox, System Identification Toolbox, Simulink) 			uct minima and discrete ng rate models o
Personal Competence				
Social Competence	Students can work in small groups o	n specific problem	ns to arrive at joint	solutions.
	Students can obtain information f documentation, experiment guides)			

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

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

Courses				
		Tree	Hum hade	CD
Title The Digital Enterprise	(1.0932)	Typ Lecture	Hrs/wk 2	CP 2
Production Planning ar		Lecture	2	2
Production Planning ar		Recitation	Section ₁	1
roduction riamming an	.u control (2000)	(small) Recitation	Soction	-
Exercise: The Digital E	nterprise (L0933)	(small)	Section 1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	INODE			
Recommended				
	Fundamentals of Production and	Quality Management	t	
Knowledge	!			
Educational Objectives		idents have reached	the following learn	ing results
Professional				
Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Children are capable of chaosing and applying models and mathods from the			
Personal Competence				
Social Competence	Students can develop joint soluti	ons in mixed teams a	and present them t	o others.
Autonomy			·	
Workload in Hours	Independent Study Time 96, Stud	dy Time in Lecture 84	4	
Credit points	6			
Course achievement				
	Written exam			
Examination duration and scale	180 Minuten			
	International Management and E	ingineering: Speciali	sation II. Product D	evelopme
	and Production: Elective Compuls		and Durado C	
	Logistics, Infrastructure and M Elective Compulsory	lobility: Specialisati	on Production an	a Logistic
	Biomedical Engineering: Specialis	sation Artificial Orga	ns and Regenerativ	e Medicin
	Elective Compulsory			
	Biomedical Engineering: Special Compulsory	alisation Implants a	and Endoprosthes	es: Electiv
	Biomedical Engineering: Specia	lisation Medical Tec	hnology and Cont	trol Theor
Assignment for	Elective Compulsory			
the Following		isation Management	and Business Ad	ministratio
	Product Development, Mater	ials and Product	ion: Specialisatio	n Produ
	Development: Elective Compulso	ry	•	
	Product Development, Materia	als and Production	n: Specialisation	Productio
	Compulsory Product Development, Materials	and Production: Sn	ecialisation Materi	als: Flectiv
	Compulsory	and moduction. 5p	cciansation Maten	ais. Liectiv
	Compulsory			
	Theoretical Mechanical Engine Production: Elective Compulsory	ering: Specialisation	n Product Develo	pment ar

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

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

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

Module M092:	1: Electronic Circuits for	Medical Applic	cations	
Courses				
Title Electronic Circuits for I	Medical Applications (L0696)	Typ Lecture	Hrs/wk	CP 3
Electronic Circuits for I	Medical Applications (L1056)	Recitation S (small)	Section 1	2
Electronic Circuits for I	Medical Applications (L1408)	Practical Course	1	1
Responsible				
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical enginee	ring		
Educational Objectives	After taking part successfully, stude	ents have reached the	following lear	ning results
Professional Competence				
Knowledge	 Students can explain the basic functionality of the information transfer by th central nervous system Students are able to explain the build-up of an action potential and it propagation along an axon Students can exemplify the communication between neurons and electronidevices 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 implant and artificial eyes 			
Skills	 Students can calculate the potential Students can give scenarios power signal acquisition. Students can develop the bl Students can define the buil eye. 	s for further improver lock diagrams of prost	ment of low-no	ise and lov
Personal Competence				
Social Competence	 Students are trained to solv teams together with experts Students are able to recognifor assistance to the right tir Students can document their results in a way that others of 	with different profess ize their specific limita ne. ir work in a clear man	ional backgrou ations, so that ner and comm	nd. they can as unicate the
	 Students are able to realisti define actions for improvement Students can break down 	ents when necessary.		

Autonomy	 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		
	CompulsorBonus Form Description		
Course achievement	No None Subject theoretical and practical work		
	No 20 % Excercises		
Examination	Oral exam		
Examination duration and scale			
_	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		

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

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

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

Module M1150	D: Continuum Mechanics			
Courses				
Title Continuum Mechanics Continuum Mechanics		Typ Lecture Recitation	Hrs/wk 2 Section 2	CP 3
	, ,	(small)		
	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 h	nave reached t	the following learr	ning results
Professional Competence				
Knowledge	The students can explain the fundame behavior of materials.	ntal concepts	to calculate the	mechanical
Skills	The students can set up balance laws specific aspects, both in applied contexts			on theory to
Personal Competence Social Competence	The students are able to develop solutio form and to develop ideas further.	ns, to present	them to specialis	sts in written
Autonomy	The students are able to assess their independently and on their own ider continuum mechanics and acquire the kr	ntify and solv	ve problems in	
Workload in Hours	Independent Study Time 124, Study Time	e in Lecture 5	6	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	45 min			
Assignment for the Following	Computational Science and Engineer Elective Compulsory Materials Science: Specialisation Modelin Mechanical Engineering and Manage Compulsory Mechatronics: Technical Complementary Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation	ng: Elective Co ement: Speci Course: Elect artificial Organ	ompulsory alisation Materia tive Compulsory as and Regeneration	als: Elective ve Medicine: es: Elective

Curricula	Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Product Development, Materials and Production: Core qualification: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Courses				
Title Material Modeling (L15	35)	Typ Lecture	Hrs/wk	CP 3
_		Recitation	Section 2	3
Material Modeling (L15	30)	(small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
	Basics of linear and nonlinear continu Mechanics II and Continuum Mechar nonlinear strain, free-body principle, energy)	nics (forces and	moments, stres	s, linear ar
Educational Objectives	After taking part successfully, student	s have reached	the following lear	ning results
Professional Competence				
Knowledge	laws			
Skills	The students can implement their o particular, the students can apply the science and evaluate the corresponding	eir knowledge to	various problem	
Personal Competence				
Social Competence	The students are able to develop so develop ideas further.	lutions, to prese	ent them to spec	ialists and
Autonomy	The students are able to assess the independently and on their own identimodeling and acquire the knowledge	ify and solve pro	blems in the area	_
Norkland in Hours	Independent Study Time 124, Study T	imo in Locturo 5		
Credit points		inc in Lecture 3		
Course achievement				
Examination	Written exam			
Examination duration and scale	45 min			
the Following	Computational Science and Engine Elective Compulsory Materials Science: Specialisation Mode Mechanical Engineering and Mana Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisat Compulsory	eling: Elective Co agement: Spec n Artificial Organ	ompulsory ialisation Materi ns and Regenerat	als: Electiv

Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective Compulsory

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

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

Module M1199	9: Advanced Functional Materials		
Courses			
Title Advanced Functional N	Materials (L1625) Typ Lecture	Hrs/wk C 2 6	CP 5
11000010101010			
Admission Requirements	None		
Recommended Previous Knowledge		Science I/II	
Educational Objectives	LATTER TAKING NART SUCCESSIUM STUGENTS NAVE REACHED	the following learning	g results
Professional Competence			
Knowledge	The students will be able to explain the properties of their applications in technology, in particular semiconductor, modern composite materials (biomater)	metallic, ceramic, p	oolymeric,
Skills	The students will be able to select material c technical needs and, if necessary, to design new ma principles from the micro- to the macroscale. The overview on modern materials science, which end materials combinations depending on the technical a	terials considering arc he students will also ables them to select	hitectural gain an
Personal Competence			
Social Competence	The students are able to present solutions to sp further.	ecialists and to deve	lop ideas
Autonomy	 The students are able to assess their own strengths and weaknesses. gather new necessary expertise by their own. 		
Workload in Hours	Independent Study Time 152, Study Time in Lecture	28	
Credit points			
Course achievement	None		
Examination	Presentation		
Examination duration and scale	30 min		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Medical le	ans and Regenerative and Endoprostheses: chnology and Control at and Business Admir	Medicine: Elective I Theory: nistration:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M127 Biology	9: MED II: Introduction t	o Biochemist	ry and M	olecula
Diology				
Courses				
Title	mistry and Molecular Biology (L0386)	Typ Lecture	Hrs/wk	CP 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	INODO			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, student	s have reached the	following learn	ing results
Professional Competence				
Knowledge	 describe basic biomolecules; explain how genetic information explain the connection between 		A;	
Skills	 The students can recognize the importance of disease; describe selected molecular-dia explain the relevance of these page 1 	agnostic procedures;		course of a
Personal Competence				
Social Competence	The students can participate in discus level.	ssions in research ar	nd medicine or	n a technica
Autonomy	The students can develop understand literature, by themselves.	ling of topics from t	he course, usi	ng technica
Workload in Hours	Independent Study Time 62, Study Tir	ne in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
	General Engineering Science (General Engineering, Focus Biomed Electrical Engineering Specialisation (General Engineering Science (Engineering, Focus Biomechanics: Corgeneral Engineering Science (Engineering Engineering Eng	mpulsory rman program): 5 man program, 7 man program, 7 chanics: Compulsory Medical Technology: glish program): 5 mpulsory	Specialisation semester): S semester): S / Elective Comp	pecialisation pecialisation pulsory

Assignment for	Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
Curricula	Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	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	
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Hans-Jürgen Kreienkamp
Language	DE
Cycle	WiSe
Content	
	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008
Literature	

Module M1333	3: BIO I: Implants and	Fracture Healing	g	
Courses				
Title Implants and Fracture	Healing (L0376)	Typ Lecture	Hrs/wk 2	CP 3
Admission Requirements	None			
	It is recommended to participat "Implants and Fracture Healing".	e in "Introduction into	Anatomie" befor	e attending
Educational Objectives	After taking part successfully, st	udents have reached th	e following learn	ing results
Professional Competence				
Knowledge	The students can describe the di for their existence. The students can name differen given fracture morphologies.	-		•
Skills	The students can determine the static situations under specific as		ne human body ເ	ınder quasi-
Personal Competence				
Social Competence	The students can, in groups, calculation of internal forces.	solve basic numeric	al modeling tas	sks for the
Autonomy	The students can, in groups, calculation of internal forces.	solve basic numeric	al modeling ta	sks for the
Workload in Hours	Independent Study Time 62, Stu	dy Time in Lecture 28		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale				
	General Engineering Science Engineering, Focus Biomechanics General Engineering Science Engineering: Compulsory General Engineering Science Mechanical Engineering, Focus B General Engineering Science Biomedical Engineering: Compul General Engineering Science Engineering: Compulsory General Engineering Science	s: Compulsory (German program): (German program, 7 iomechanics: Compulso (German program, 7 sory (English program):	Specialisation semester): Spory semester): Spory Specialisation	Biomedical pecialisation pecialisation Biomedical
Assignment for the Following Curricula	Engineering, Focus Biomechanics General Engineering Science Mechanical Engineering Focus B	s: Compulsory (English program, 7 iomechanics: Compulso (English program, 7 sory sation Biomechanics: C	semester): Spory semester): Spory	oecialisation

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

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

Module M1334	4: BIO II: Biomaterials		
Courses			
Title Biomaterials (L0593)	TypHrs/wkCPLecture23		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.		
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.		
Personal Competence			
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.		
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2

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

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berli Springer, 1996.	١,

Courses					
Title Finite Element Method	s (L0291)		Typ Lecture	Hrs/wk	CP 3
Finite Element Method	s (L0804)		Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	LNIONE				
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 succes	ssfully, students	have reached	the following lear	ning results
Professional Competence					
Knowledge	The students possess a element method and a basis of the method.				
Skills	The students are capa finite elements, assem resulting system of equ	bling the corres			
Personal Competence					
Social Competence	Students can work in si	mall groups on sp	pecific problem	s to arrive at join	t solutions.
Autonomy	The students are able and develop own finite are critically scrutinized	element routine			
Workload in Hours	 Independent Study Tim	e 124, Study Tin	ne in Lecture 5	6	
Credit points	Independent Study Time 124, Study Time in Lecture 56 6				
Course achievement	CompulsorBonus No 20 %	Form Midterm	D	escription	
Examination	Written exam				
Examination duration and scale					
	Civil Engineering: Core Energy Systems: Core Aircraft Systems Engine Aircraft Systems Engine	qualification: Elec eering: Specialisa	ctive Compulso ation Aircraft S	ystems: Elective (

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

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

Module M1342	2: Polymers				
Courses					
	es of Polymers (L0389) with polymers (L1892)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3	
Module Responsible	Dr. Hans Wittich				
Admission Requirements	None				
Recommended Previous Knowledge	Basics: chemistry / physics / mater	rial science			
Educational Objectives	After taking part successfully, stud	lents have reached th	e following learr	ing results	
Professional Competence					
-	Students can use the knowledge analysis.	•	_	_	
Knowledge	They can explain the complex rela	tionships structure-pr	operty relationsl	nip and	
	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).				
	Students are capable of				
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.				
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.				
Personal					
Competence	Students can				
		eterogenius groups a	nd document the	am	
Canial Communication	 arrive at funded work results in heterogenius groups and document them. provide appropriate feedback and handle feedback on their own performance 				
Social Competence	constructively.	and nandie reedback	on their own [performance	
	Students are able to				
	- assess their own strengths and weaknesses.				
Autonomy	- assess their own state of learn steps on this basis.	ing in specific terms	and to define t	urther work	
	- assess possible consequences of	their professional act	ivity.		
	Independent Study Time 124, Stud	ly Time in Lecture 56			
Credit points					
Course achievement	None				
Examination					
Examination duration and					

scale	
Assignment for the Following Curricula	Compulsory

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

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

Module M0632	2: Regenerative	Medicine			
Courses					
Title Regenerative Medicine Lecture Tissue Enginee	e (L0347) ering - Regenerative Med	icine (L1664)	Typ Seminar Seminar	Hrs/wk 2 2	CP 3 3
Module Responsible	Prof. Ralf Pörtner				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part succe	essfully, students h	ave reached the fo	ollowing learn	ing results
Professional Competence					
Knowledge	After successful comp basic methods of rege different methods of t methods for the cultiv The students can of regenerative medicin discussed topics.	nerative medicine tissue engineering ation of animal and outline the actua	and to explain the They are able to I human cells.	use of the tisgive a basic Tissue Engin	sue cells for overview of eering and
Skills	 After successful completion of the module students are able to use medical databases for acquirierung and presentation of relevant up-to-date data independently able to present their work results in the form of presentations able to carry out basic cell culture methods and the corresponding analysis independently able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 				
Personal Competence Social Competence	Students are able to wand discuss their results are able to rateachers.	lts in the plenary a	nd to defend them	1.	
Autonomy	After completion of to problem in teams of a the results.	approx. 2-4 person	s independently ir		
	Independent Study Tir	me 124, Study Tim	e in Lecture 56		
Credit points					
Course achievement	CompulsorBonus Yes 20 %	Form Written elaborat	ion Ausarl	ription beitung zu Rir ocol for lecture	
Examination	Presentation				

Examination duration and scale	Oral presentation + discussion (30 min)
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

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

Module M0548	B: Bioelectromagne	tics: Prin	ciples ar	nd App	licatio	ns
Courses						
_	Principles and Applications (L03)		Typ Lecture Recitation (small)	Section	Hrs/wk 3	CP 5
Module Responsible	Prof. Christian Schuster		(Silidii)			
Admission Requirements						
Recommended Previous Knowledge	Basic principles of physics					
Educational Objectives	After taking part successfull	y, students h	ave reached	the follow	ving learn	ing results
Professional Competence						
Knowledge	Students can explain the bioelectromagnetics, i.e. the in biological tissue. They contains the phenomena and order therefields. They can give an overcharacterization of electromexamples for therapeutic amedical technology.	e quantification an define ar m correspond erview over n magnetic field	on and appliced on and exemplify ding to wave measurement is in practical on and application.	the moselength at and numer applica	electroma st importand frequinerical te- nerical te- tions . Th	gnetic fields ant physica ency of the chniques for ey can give
Skills	Students know how to ap electromagnetic fields in bio make use of the elementa assess the most important they can order the efferespectively, and they can develop validation strategie effects of electromagnetic make an appropriate choice	logical tissue ry solutions effects that ects corresp analyze ther es for their p fields for the	e. In order to of Maxwell's these model onding to m in a quant predictions. T	do this to Equation so predict wavelend titative ware	they can r ns. They for biolo gth and vay. They able to e	elate to and are able to gical tissue frequency are able to evaluate the
Personal Competence Social Competence	Students are able to work t are able to present their i					
Autonomy	Students are capable to good publications and relate that to make a connection between content of other lectures (relectrical engineering / physical of bioelectromagnetics)	information to teen their kn e.g. theory co ics). They ca	to the contex lowledge obt of electroma	ct of the lace and	ecture. Tl this lectu elds, fund	ney are able are with the amentals o
Workload in Hours	Independent Study Time 110), Study Time	e in Lecture 7	70		

Credit points	6			
Course achievement	CompulsorBonus Yes 10 %	Form Presentation	Description	
Examination		resementor		
Examination duration and scale	45 min			
the Following	Electromagnetic Com Electrical Engineering International Manage Elective Compulsory Biomedical Engineeri Elective Compulsory Biomedical Engineer Compulsory Biomedical Engineeri Elective Compulsory Biomedical Engineeri Elective Compulsory Theoretical Mechanic Compulsory	apatibility: Elective (g: Specialisation Medement and Engineer ng: Specialisation Aring: Specialisation ring: Specialisation ing: Specialisation cal Engineering: Teach and Engineering: Teach are specialisation cal Engineering: Teach and Engineering: Teach are specialisation cal Engineering: Teach and Engineering: Teach are specialisation cal Engineering: Teach are specialisation are specialisation.	Microwave Engineering, Compulsory dical Technology: Elective Conng: Specialisation II. Electrical Computer and Regeneral Implants and Endoprosthe Medical Technology and Computer and Business Americal Complementary Compecialisation Bio- and Medical Complementary Compecialisation Bio- and Medical Computer and Medical Complementary Computer and Medical Computer and M	mpulsory al Engineering: ative Medicine: eses: Elective ontrol Theory: Administration: urse: Elective

	electromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
	- 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 \ensuremath{FDTD})
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics",
	CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Content Con	Course L0373: Bioe	electromagnetics: Principles and Applications
CP Workload in Hours Independent Study Time 2, Study Time in Lecture 28	Тур	Recitation Section (small)
Independent Study Time 2, Study Time in Lecture 28 Lecturer	Hrs/wk	2
Lecturer Prof. Christian Schuster DE/EN	СР	1
Language DE/EN Cycle SoSe - Fundamental properties of electromagnetic fields (phenomena) - Mathematical description of electromagnetic fields (Maxwell's Equations) - Electromagnetic properties of biological tissue - Principles of energy absorption in biological tissue, dosimetry - Numerical methods for the computation of electromagnetic fields (especia 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 very high frequency in biological tissue - Behavior of electromagnetic fields of very high frequency in biological tissue - Diagnostic applications of electromagnetic fields in medical technology - Therapeutic applications of electromagnetic fields in medical technology - The human body as a generator of electromagnetic fields - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetic CRC (2009) - A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues Wiley (2006) Literature - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Acader Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects	Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Cycle SoSe - Fundamental properties of electromagnetic fields (phenomena) - Mathematical description of electromagnetic fields (Maxwell's Equations) - Electromagnetic properties of biological tissue - Principles of energy absorption in biological tissue, dosimetry - Numerical methods for the computation of electromagnetic fields (especia FDTD) - Measurement techniques for characterization of electromagnetic fields - Behavior of electromagnetic fields of low frequency in biological tissue - Behavior of electromagnetic fields of medium frequency in biological tissue - Behavior of electromagnetic fields of wery high frequency in biological tissue - Behavior of electromagnetic fields of very high frequency in biological tissue - Diagnostic applications of electromagnetic fields in medical technology - Therapeutic applications of electromagnetic fields in medical technology - The human body as a generator of electromagnetic fields - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetic CRC (2009) - A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues Wiley (2006) - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Acader Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects		
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- Principles of energy absorption in biological tissue, dosimetry - Numerical methods for the computation of electromagnetic fields (especial 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 - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetic CRC (2009) - A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues Wiley (2006) - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Acader Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects		- Mathematical description of electromagnetic fields (Maxwell's Equations)
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- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues Wiley (2006) - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Acader Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects		- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics",
Wiley (2006) - S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Acader Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects		CRC (2009)
Press (2008) - F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects		- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
		- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Module M138 Engineering	4: Case Studies for Reger	nerative M	ledicine and	l Tissue
Courses				
Title Case Studies for Reger (L1963)	nerative Medicine and Tissue Engineering	Typ Seminar	Hrs/wk 3	CP 6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students	have reached t	he following learn	ing results
Professional Competence Knowledge Skills				
Personal Competence Social Competence				
Autonomy Workload in Hours	Independent Study Time 138, Study Tin	ne in Lecture 42)	
Credit points	· · · · · · · · · · · · · · · · · · ·			
Course achievement	None			
Examination	Presentation			
Examination duration and scale				
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Compulsory	Artificial Organ	s and Regenerativ	e Medicine:

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

Module M0630	0: Robotics and	Navigation i	n Medicine		
Courses					
Title Robotics and Navigation	on in Medicine (L0335)		Typ Lecture	Hrs/wk 2	CP 3
Robotics and Navigation			Project Seminar	2	2
Robotics and Navigation			Recitation Sect (small)	ion 1	1
Module Responsible	IPINI AIPYANNEI SCHIAF	efer			
Admission Requirements	None				
Recommended Previous Knowledge	 principles of pro 	ath (algebra, analys ogramming, e.g., in b skills			
Educational Objectives	After taking part succe	essfully, students h	ave reached the fol	llowing learn	ing results
Professional					
Competence		lain kinamatian an	al turn aldunar arrata una	in aliminal a	
Knowledge	The students can exp illustrate systems and respect to collision d typical systems regard	d their components letection and saf	s in detail. Systems ety and regulation	s can be eva	aluated with
Skills	systems for medical a	The students are able to design and evaluate navigation systems and robotic systems for medical applications.			
Personal Competence					
Social Competence	The students discuss incoorporate feedback		r groups, provide h	elpful feedb	ack and car
Autonomy	The students can refl They can present the			he results of	f their work
Workload in Hours	Independent Study Tir	me 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 % Yes 10 %	Form Written elaborati Presentation	Descri ion	ption	
Examination	Written exam				
Examination duration and scale					
	Computer Science: Sp Electrical Engineering: Computational Science Robotics: Elective Con International Manager Elective Compulsory Mechatronics: Special Biomedical Engineerin Elective Compulsory Biomedical Engineerin	: Specialisation Medice and Engineering inpulsory ment and Engineering isation Intelligent Sag: Specialisation A	dical Technology: Elg: Specialisation Sying: Specialisation I ystems and Robotic rtificial Organs and	lective Composite of the composite of th	oulsory neering and Engineering Compulsory ve Medicine:

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

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

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

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

Module M0634	4: Introduction i	nto Medical	Technology an	d Syst	ems
Courses					
Courses			_	, .	
	cal Technology and Systen cal Technology and Systen		Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Introduction into Medic	cal Technology and Systen	ns (L1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaef	er			
Admission Requirements	None				
Recommended Previous Knowledge	principles of stochastic	S	ulus)		
Educational Objectives	After taking part succes	ssfully, students h	ave reached the follow	wing learn	ing results
Professional Competence					
Knowledge	The students can exp systems, computer aid to give an overview of	ed surgery, and m	nedical information sy	stems. Th	ey are able
Skills	The students are able clinical applications.	to evaluate syste	ms and medical dev	ices in the	e context of
Personal Competence					
Social Competence	The students describe tasks that are solved in		dical technology as	a project,	and define
Autonomy	The students can refle They can present the re			results of	their work.
Workload in Hours	Independent Study Tim	e 110, Study Time	in Lecture 70		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 % Yes 10 %	Form Written elaborati Presentation	Descript ion	ion	
Examination	Written exam				
Examination duration and scale					
Assignment for the Following	General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computer Science: Sp Compulsory Electrical Engineering: General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computational Science Elective Compulsory	ry Science (Germany: Compulsory Decialisation Compulsory Core qualification: Science (Englistry Science (Englishy: Compulsory	outer and Software Elective Compulsory h program): Speci	ester): Spendineering ialisation ester): Spendine	pecialisation ng: Elective Biomedical pecialisation
	•				

Curricula	Computational Science and Engineering: Specialisation Computer Science: Elective
	Compulsory
	Computational Science and Engineering: Specialisation Mathematics & Engineering
	Science: 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
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

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

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

Module M0752	2: Nonlinear Dynamics
Courses	
Title Nonlinear Dynamics (L	Typ Hrs/wk CP 0702) Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	to develop and research new terms and concepts.
Skills -	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.
Personal Competence	
Social Competence	Students can reach working results also in groups.
Autonomy	Students are able to approach given research tasks individually and to identify and follow up novel research tasks by themselves.
	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
-	Written exam
Examination duration and scale	
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

Courses				
Title Semiconductor Techno Semiconductor Techno		Typ Lecture Practical Course	Hrs/wk 4 2	CP 4 2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, mater	ial science and semicond	luctor device)S
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 to describe and to explain substrates, to discuss in details the relevimpact thereof on the fabrication and to present integrated process 	rant fabrication processe of semiconductor device	s, process fl	ows and th
Skills	 Students are capable to analyze the impact of proce to select and to evaluate proce to develop process flows for the 	esses and	_	
Personal Competence				
Social Competence	Students are able to prepare and well as to present and discuss the			am work a
Autonomy	None			
Workload in Hours	Independent Study Time 96, Study	Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination				

duration and scale	
Assignment for the Following Curricula	

	Liective Compuisory
Course L0722: Sem	niconductor Technology
	Lecture
Hrs/wk	
СР	
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski, Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD
	 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)
	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
Literature	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	 K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M083!	5: Hu	ımanoid	d Robo	otics					
Courses									
Title Humanoid Robotics (LC	0663)					Typ Seminar		Hrs/wk 2	CP 2
Module Responsible	Patrick	k Göttsch							
Admission Requirements	None								
Recommended Previous Knowledge	•	Introduction							
Educational Objectives	I ATTOL I	aking part	success	fully, st	tudents l	nave reache	d the follo	wing learn	ing results
Professional Competence									
Knowledge		Students of Students of Irobotics.				obots. trol concept	s for diffe	rent tasks	in humanoid
Skills	•	 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									
Social Competence	,	present th	nem able to	provi	de appr	ing solution			
Autonomy		presentati Students	ion for sp familiariz	pecific t ze them	tasks and nselves v	and draw d select the vith a scient r students, s	best solut ific field, a	ion are able of	introduce i
Workload in Hours	Indepe	endent Stu	dy Time	32, Stu	ıdy Time	in Lecture 2	28		
Credit points									
Course achievement									
Examination Examination duration and scale	30 mir								
	Electri Compu Mecha Mecha Biome	ulsory atronics: Sp atronics: Sp	pecialisat neering:	tion Inte	elligent S stem Des	Control a Systems and Sign: Elective Artificial Org	l Robotics e Compuls	: Elective (sory	Compulsory

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

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

Module M083	8: Linear and Nonline	ar System Identifi	kation		
Courses					
Title Linear and Nonlinear S	System Identification (L0660)	Typ Lecture	Hrs/wk CP 2 3		
Module Responsible	Prof. Herbert Werner				
Admission Requirements	INONE				
Recommended Previous Knowledge	 Discrete-time systems 	value decomposition			
Educational Objectives	LATTER TAKING NART SHCCESSTHING	students have reached the	following learning results		
Professional Competence					
Knowledge	 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 Kalmar realisation theory 				
Skills	 Students are capable of applying the predicition error method to the experimental identification of linear and nonlinear models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model They are capable of 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					
Social Competence	Students can work in mixed gro	oups on specific problems	to arrive at joint solutions.		
Autonomy	Students are able to find requirerature, software documenta				
Workload in Hours	Independent Study Time 62, St	cudy Time in Lecture 28			
Credit points					
Course achievement	LNODE				
Examination	Oral exam				
Examination duration and scale	30 min				
	Electrical Engineering: Spec Compulsory Mechatronics: Specialisation In	ialisation Control and telligent Systems and Rob	-		

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

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

Courses										
Title Optimal and Robust Co Optimal and Robust Co						Typ Lecture Recitat	tion	Sectio	Hrs/wk 2	CP 3
•						(small))			<u> </u>
Module Responsible		Herbert \	Werner							
Admission Requirements	None									
Recommended Previous Knowledge	•	State s	pace me	thods	-	ponse, rod ecomposi		s)		
Educational Objectives	After	taking pa	art succe	essfully,	student	s have rea	ached	the follo	wing learr	ning result
Professional Competence										
Knowledge	•	 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. 								
Skills	•	multiva They al form of it. They ar control carrying They ar system They ar matrix They car	riable plore capab re capab loops in g out a n re capab , and of or re capab inequalit	ant mod ble of re ralized p le of tra nto con nixed-se ble of co designir ble of fo cies (LMI out all	dels. epresent plant, an inslating straints ensitivity onstruction g a mix ormulatir l), and of of the	ing a H2 d of using time and on close design. ng an LFT ed-objecti g analysi	or H-i g stand frequ d-loop unce ve rob s and indard	nfinity dard sof ency do sensiti tainty r ust conf synthes LMI-sol	LQG cordesign profession spectification with the condition of the conditio	oblem in s for solv ifications ons, and an uncertons as lin lving ther
Personal Competence										
Social Competence				_	-				-	
Autonomy						formation nd use it to			rovided (le problems.	cture not

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory 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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

ourses				
itle larketing of Innovatior		Typ Lecture Project-/problem-	Hrs/wk 4	CP 4
BL Marketing of Innov	ations (L0862)	based Learning	1	2
•	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous Knowledge	 Module International Busine Basic understanding of bus decision theory, project ma Bachelor-level Marketing Competitor Strategies, Basi Unerstanding the difference Understanding of the impomarkets Good English proficiency; p 	iness administration princi nagement, international be Knowledge (Marketing Insics of Buying Behavior) es beweetn B2B and B2C n rtance of managing innova	usiness) struments, narketing	Market ar
Educational Objectives	After taking part successfully, stud	dents have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	 Students will have gained a deep Specific characteristics in the Approaches for analyzing the development The gathering of information Concepts and approaches product and service develor Approaches and tools for each of new products and innovation Marketing mix elements requirements and challenged Pricing methods for new products and innovation The organization of comple Communication concepts a 	he marketing of innovative he current market situation on about future customer not to integrate lead users pment processes ensuring customer-orientative services that take into consider of innovative products a coducts and services x sales forces and persona	eeds and read and their ion in the dideration to the services	ture mark quirements needs in evelopmer he specif
Skills	 Design and to evaluate strategies Analyze markets by applyir Conduct forecasts and dev planning Translate customer needs and successfully apply adviservice development Use adequate methods to f services Choose suitable pricing innovations Make strategic sales decisisales channels) 	decisions regarding management of the decisions regarding management of the decisions regarding management of the decision of	oortfolios as a basis and marke er-oriented innovative p	for strateg table offer product an roducts an

Competence	
	The students will be able to
Social Competence	 have fruitful discussions and exchange arguments develop original results in a group present results in a clear and concise way carry out respectful team work
Autonomy	 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	
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective 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

services, model, objectives and examples of innovation marketin characteristics of services, challenges of service marketing) II. Methods and approaches of strategic marketing planning • patterns of industrial development, patent and technology portfolios III. Strategic foresight and scenario analysis • objectives and challenges of strategic foresight, scenario analysis, Delgmethod IV. User innovations • Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis V. Customer-oriented Product and Service Engineering • Conjoint Analysis, Kano, OFD, Morphological Analysis, Blueprinting VII. Pricing • Basics of Pricing, Value-based pricing, Pricing models VIII. Sales Management • Basics of Sales Management, Assessing Customer Value, Planning Custom Visits IX. Communications • Diffusion of Innovations, Communication Objectives, Communication Instruments Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technolog products and innovations, third edition, Pearson education. ISBN-1 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (35 365), Chapter 12 (419-426). Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition McGrw Hill, Boston et al., 2008 Christenen, C. M. (1997). Innovator's Dilemma: When New Technologies Caus Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?, p. 3-24. Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boste et al., McGraw Hill Tidd: J. & Hull, Frank M. (Editors) (2007) Service Innovation, London	Course L2009: Mar	keting of Innovations
CP Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Prof. Christian Lüthje Language EN Cycle SoSe I. Introduction Innovation and service marketing (importance of innovative products an services, model, objectives and examples of innovation marketin characteristics of services, challenges of service marketing) II. Methods and approaches of strategic marketing planning patterns of industrial development, patent and technology portfolios III. Strategic foresight and scenario analysis objectives and challenges of strategic foresight, scenario analysis, Delgmethod IV. User innovations Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis Content V. Customer-oriented Product and Service Engineering Conjoint Analysis, Kano, OFD, Morphological Analysis, Blueprinting WII. Pricing Basics of Pricing, Value-based pricing, Pricing models VIII. Sales Management Basics of Sales Management, Assessing Customer Value, Planning Custom Visits IX. Communications Diffusion of Innovations, Communication Objectives, Communication Diffusion of Innovations, third edition, Pearson education. ISBN-1 1292040335. Chapter 10 (1419-426). Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition McGrow Hill, Boston et al., 2008 Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Caus Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?, p. 3-2-24. Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boste et al., McGraw Hill Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London	Тур	Lecture
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von hipper, c.(2005). Democratizing innovation, Cambridge: Mili Press		Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

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

Module M0938	B: Bioprocess Engineering -	Fundamentals		
Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering	g - Fundamentals (L0841)	Lecture Section	2	3
Bioprocess Engineering	g- Fundamentals (L0842)	Recitation Section (large)	12	1
Bioprocess Engineering	g - Fundamental Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous Knowledge	none, module "organic chemistry", modu	ule "fundamentals for	process er	ngineering"
Educational Objectives	After taking part successfully, students h	nave reached the follo	wing learn	ing results
Professional Competence				
Knowledge	are able to classify different types of ki well as to differentiate different types of and rheology can be named and mass explained. The students are capal	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.		
Skills	 After successful completion of this module describe different kinetic approach calculate the corresponding parare. predict qualitatively the influen redox equivalents and growth inh analyze bioprocesses on basis metabolic flux equations distinguish between scale-up bioprocesses (anaerobic, aerobic as well as to apply them to current propose solutions to complicated the corresponding models to explore new knowledge resource identify scientific problems with solutions. to document and discuss their paranner 	hes for growth and sumeters ce of energy general ibition on the ferment of stoichiometry an criteria for differe as well as microaero it biotechnical probler biotechnological process and to apply the neconcrete industrial	ation, regeration proceed to set ent biore objects and the set ent biore objects and the set ent biore objects and the set end	eneration of ess up / solver actors and mpare then do deduced to deduced to formulate to formulate endiced contents to formulate endiced contents and the endiced contents
Personal Competence Social Competence	After completion of this module partic questions in small teams to enhance opinions and increase their capacity fenvironments.	the ability to take or teamwork in engi	position to neering a	o their owr nd scientifi
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		

Credit points	6
Course achievement	Cubicot theoretical and
Examination	Written exam
Examination duration and scale	90 min
	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

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

Course L0842: Bioprocess Engineering- Fundamentals			
Тур	Typ Recitation Section (large)		
Hrs/wk	2		
СР	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language			
Cycle			
	1. Introduction (Prof. Liese, Prof. Zeng)		
	2. Enzymatic kinetics (Prof. Liese)		
	3. Stoichiometry I + II (Prof. Liese)		
	4. Microbial Kinetics I+II (Prof. Zeng)		
Content	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: Biop	Course L0843: Bioprocess Engineering - Fundamental Practical Course		
Тур	Practical Course		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language	DE		
Cycle	SoSe		
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.		
Literature	Skript		

Module M1143	3: Mechanical Design Metho	dology		
Courses				
Title Mechanical Design Med Mechanical Design Med		Typ Lecture Recitation (small)	Hrs/wk 3 Section 1	CP 4 2
Module Responsible	Prof. Josef Schlattmann	(Smail)		
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached	the following learn	ing results
Professional Competence		esian conside	oring targeted ar	unlication of
Knowledge	specific product design techniques	-		
Skills	Creative handling of processes used for complex product design problems / techniques following theoretical aspects.	Application	reparation and fo of various prod	rmulation of duct design
Personal Competence				
Social Competence				
Autonomy				
Credit points	Independent Study Time 124, Study Tim	e in Lecture 5	6	
Course				
achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the Following Curricula	I Droduct Dovolonment Materials a	sign: Elective of Artificial Organia Implants and Medical Technology of the Management and Production Specialisation	Compulsory as and Regenerative and Endoprosthese annology and Content and Business Add and Specialisation cialisation Product ecialisation Materi Product Develo	ve Medicine: es: Elective trol Theory: ministration: on Product ion: Elective als: Elective

Compulsory

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

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

Module M1277	7: MED I: Introduction to Anatomy	
Courses		
Title Introduction to Anatom	Typ Hrs/wk CP my (L0384) Lecture 2 3	,
Module Responsible	Prof. Udo Schumacher	
Admission Requirements	INONE	
Recommended Previous Knowledge	None	
Educational Objectives	After taking part successfully, students have reached the following learning in	results
Professional Competence		
Knowledge	The students can describe basal structures and functions of internal organs musculoskeletal system. The students can describe the basic macroscopy and microscopy of those sy	
Skills	The students can recognize the relationship between given anatomical facts development of some common diseases; they can explain the relevant structures and their functions in the context of widespread diseases.	
Personal Competence		
_	The students can participate in current discussions in biomedical resea medicine on a professional level.	rch and
Autonomy	The students are able to access anatomical knowledge by themselv participate in conversations on the topic and acquire the relevant knowledge by themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	s 3	
Course achievement		
	Mritten exam	
Examination duration and scale	g 90 minutes	
	General Engineering Science (German program): Specialisation Med Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Bio Engineering: Compulsory	
the Following	General Engineering Science (German program, 7 semester): Special Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Special Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Medical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Special Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Special Biomedical Engineering: Compulsory	alisation ory chanical omedical alisation

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		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Lange	
Language		
Cycle		
	General Anatomy	1
	1 st week:	The Eucaryote Cell
	2 nd week:	
	2" week:	The Tissues
	3 rd week:	Cell Cycle, Basics in Development
	4 th week:	Musculoskeletal System
		Museuloskeietai system
	5 th week:	Cardiovascular System
	6 th week:	Respiratory System
	7 th week:	Genito-urinary System
Content	8 th week:	Immune system
	9 th week:	Digestive System I
	10 th week:	Digestive System II
	11 th week:	Endocrine System
	12 th week:	Nervous System
	13 th week:	Exam
Literature	Adolf Faller/Michae Stuttgart, 2012	l Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag

Courses				
Γitle	Typ Hrs/wk CP			
	ogy and Radiation Therapy (L0383) Lecture 2 3			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Therapy The students can distinguish different types of currently used equipmed respect to its use in radiation therapy. The students can explain treatment plans used in radiation the interdisciplinary contexts (e.g. surgery, internal medicine). The students can describe the patients' passage from their admittance through to follow-up care.				
	Diagnostics			
Knowledge	The students can illustrate the technical base concepts of projection radiography including angiography and mammography, as well as sectional imaging technique (CT, MRT, US).			
	The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.			
	The students can choose the right treatment method depending on the patien clinical history and needs.			
	The student can explain the influence of technical errors on the imaging technique			
	The student can draw the right conclusions based on the images' diagnosti findings or the error protocol.			
	Therapy The students can distinguish curative and palliative situations and motivate withey came to that conclusion.			
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.			
	The students can use the therapeutic principle (effects vs adverse effects)			
	The students can distinguish different kinds of radiation, can choose the best of depending on the situation (location of the tumor) and choose the energy needed that situation (irradiation planning).			
The student can assess what an individual psychosocial service should loc (e.g. follow-up treatment, sports, social help groups, self-help groups, services, psycho-oncology).				
Diagnostics				

	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.						
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.						
Personal Competence							
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.						
	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.						
Autonomy	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.						
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28						
Credit points	3						
Course achievement	INONA						
Examination	Written exam						
Examination duration and scale							
the Following	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering: Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine:						

Course L0383: Introduction to Radiology and Radiation Therapy			
Тур	Lecture		
Hrs/wk	2		
СР	3		

,	Independent Study Time 62, Study Time in Lecture 28 Prof. Ulrich Carl, Prof. Thomas Vestring					
Language	DE					
Cycle						
Content	The students will be given an understanding of the technological possibilit in the field of medical imaging, interventional radiology and radiat therapy/radiation oncology. It is assumed, that students in the beginning the course have heard the word "X-ray" at best. It will be distinguish between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) a therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend special big units, which determine a predefined sequence in their respect departments					
	"Technik der medizinischen Radiologie" von T. + J Laubenberg – T. A. Giran D. A. L. Giran B. A. Giran D. Gir					
	7. Auflage – Deutscher Ärzteverlag – erschienen 1999					
	 "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumani 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					
Literature	 "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 - erschiener 18.07.2012					
	ISBN: 978-3-13-329716-5					
	 "Praxismanual Strahlentherapie" von Stöver / Feyer - 					
	1. Auflage - Springer-Verlag GmbH - erschienen 02.06.2000					
	2.7.a.iage Spinige. Venag Ciribit Ciscinenci 32.00.2000					

Module M1280	0: MED II: Introduction to Physiology				
Courses					
Title Introduction to Physiol	Typ Hrs/wk CP logy (L0385) Lecture 2 3				
Module Responsible	Dr. Roger Zimmermann				
Admission Requirements	None				
Recommended Previous	None				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge	 The students can describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 				
Skills	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					
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.				
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves.				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Credit points	3				
Course achievement	LNONE				
Examination	Written exam				
Examination duration and scale	60 minutes				
scale	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory				
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation				
	Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
Assianment for	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory				
the Following	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory				
	General Engineering Science (English program, 7 semester): Specialisation				

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

Module M1332	2: BIO I: Experimental M	ethods in Biom	echanics	
Courses				
Title Experimental Methods	in Biomechanics (L0377)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to participat attending "Experimentelle Methode		nd Frakturheilu	ng" before
Educational Objectives	After taking part successfully, stude	ents have reached the	following learn	ing results
Professional Competence				
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under given fracture morphologies.			
	The students can describe differmovements, and choose the adequ		•	forces and
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.			
Personal Competence				
Social Competence	The students can, in groups, solve basic experimental tasks.			
Autonomy	The students can, in groups, solve I	·	ks.	
	Independent Study Time 62, Study	Time in Lecture 28		
Credit points				
Course achievement				
	Written exam			
Examination duration and scale	90 min			
	General Engineering Science (General Engineering, Focus Biomechanics: General Engineering Science (General Engineering Science (General Engineering Science (General Engineering, Focus Bior General Engineering Science (G	Compulsory German program): erman program, 7 nechanics: Compulsor	Specialisation semester): Sp	Biomedical
tne Following	Biomedical Engineering: Compulsor General Engineering Science (Engineering: Compulsory General Engineering Science (Engineering, Focus Biomechanics: C General Engineering Science (E Mechanical Engineering, Focus Bior General Engineering Science (E Biomedical Engineering: Compulsor Mechanical Engineering: Specialisat	English program): English program): Compulsory nglish program, 7 nechanics: Compulsor nglish program, 7	Specialisation Specialisation semester): Spy semester): Sp	Biomedical Mechanical pecialisation

Biomedic	cal Engineering: Specialisation Artificial Organs and Regenerative M	edicine:
Elective (Compulsory	
Biomedic	cal Engineering: Specialisation Implants and Endoprostheses:	Elective
Compulso	ory	
Biomedic	cal Engineering: Specialisation Medical Technology and Control	Theory:
Elective (Compulsory	-
Biomedic	cal Engineering: Specialisation Management and Business Adminis	stration:
	Compulsory	
Technom	nathematics: Specialisation III. Engineering Science: Elective Comput	lsory

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

Module M1335	5: BIO II: Artificial Joint	Replacement		
Courses				
Title Artificial Joint Replacement (L1306)		Typ Lecture	Hrs/wk 2	CP 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students can name the different kinds of artificial limbs.			
Skills	The students can explain the advantages and disadvantages of different kinds of endoprotheses.			
Personal Competence				
Social Competence	The students are able to discuss issues related to endoprothese with student mates and the teachers.			
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.			
Workload in Hours	Independent Study Time 62, Stud	ly Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Medical lechnology and Control Theory:			

Course L1306: Arti	ficial Joint Replacement		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	SoSe		
Content	 Inhalt (deutsch) EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren) DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 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	5: Feedback Control in I	Medical Technol	logy	
Courses				
Title Feedback Control in Me	edical Technology (L0664)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Jonannes Kreuzer			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in Control, Basics in Physiol	logy		
Educational Objectives	After taking part successfully, stud	dents have reached the	following learn	ing results
Professional Competence				
	The lecture will introduce into the engineering point of view. Fundaintroduced like knowledge in control	amentals in human pl		
Knowledge	Internal control loops of the huma design of external closed loop sys			
	The handling of PID controllers a fuzzy controller or neural netwo equivalent circuits will be discusse	orks will be illustrated		
Skills	Application of modeling, identific technology.	ation, control technolo	ogy in the field	l of medical
Personal Competence				
Social Competence	Students can develop solutions t their results (e.g. during project w	o specific problems in eek)	small groups	and present
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.			
Workload in Hours	Independent Study Time 62, Study	y Time in Lecture 28		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and scale				
Assignment for the Following Curricula	Biomedical Engineering: Specialis	sation Control and isation Implants and ation Artificial Organs a	Power System Endoprosthese and Regenerative	ns: Elective es: Elective ve Medicine:

Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory

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

p ture citation	Hrs/wk 2 Section ₂	CP 3
nall)		-
esign, linea	ar matrix inequa	lities
reached th	he following lear	ning results
f nonlinear erformance ques can be FT represe es associate etic concept systems properties eis condition els e represen ed according	r systems in the feet conditions for the used to solve the entations of LPV the ted with each of the pts are used to respond to an actuator the bounded respond to a solution to the property of the property	form of quasi LPV systems analysis and systems and these model represent the er consensus control loops ally invariant /sensor array
of gain-sch LPV model re tools (Ma	fatlab robust cor	ers; they car ntrol toolbox or groups o
ec	I format	I formation controllers f using Matlab tools provic

	 Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox 				
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	None				
Examination	Oral exam				
Examination duration and scale					
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory				

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

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

Specialization Management and Business Administration

Courses					
Courses			T	Uma (sada	- CD
Title Intelligent Systems in	Medicine (L0331)		Typ Lecture	Hrs/wk 2	CP 3
Intelligent Systems in			Project Seminar	2	2
Intelligent Systems in	Medicine (L0333)		Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schlae	fer			
Admission Requirements	INIONA				
Recommended Previous Knowledge	 principles of store 	gramming, Java/C-			
Educational Objectives	TALLEL TAKING DALL SILCE	essfully, students h	ave reached the follo	wing learn	ing results
Professional					
Competence	;	to analyze and cal	va aliniaal traatmaant	nlanning s	and decision
Knowledge	The students are able to analyze and solve clinical treatment planning and decision support problems using methods for search, optimization, and planning. They are able to explain methods for classification and their respective advantages and disadvantages in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate methods in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privacy and safety requirements.				
Skills	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.				
Personal Competence					
Social Competence	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work.				
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tim	ne 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	1 Yac 10 %	Form Written elaborati Presentation	Descript on	ion	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Spe Electrical Engineering: Computational Science	Specialisation Med	lical Technology: Elec	tive Comp	oulsory

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

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

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

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

Module M0629	9: Intelligent Autonomous	Agents and	d Cogi	nitive I	Robotics
Courses					
Title Intelligent Autonomous	s Agents and Cognitive Robotics (L0341) s Agents and Cognitive Robotics (L0512)	Typ Lecture Recitation (small)	Section	Hrs/wk 2 2	CP 4 2
Module Responsible	Rainer Marrone	(0			
Admission Requirements	None				
Recommended Previous Knowledge	Vectors, matrices, Calculus				
Educational Objectives	After taking part successfully, students	have reached t	he follov	wing learn	ing results
Professional Competence					
Knowledge	Students can explain the agent abstrated behavior, and give details about agent can describe the main features of encooperation can be discussed in terms olving these problems. For dealing students can summarize how Bayesian representation and reasoning formalist students can define decision making pawith and with complete access to the students can describe techniques for students can identify techniques for can explain planning techniques for accoordination problems and decision different types of equilibria, social choices design techniques.	t design (goals, vironments. The ms of decision go with uncertain networks can min static and procedures in site state of the solving (partially ques for measure simultaneous lochieving desired making in a medical making in a medical procedures of the solving (partially ques for measures of the solving (partially ques for measures) and the solving desired making in a medical making in a medical procedure.	utilities, e notion problem nty in be employnamic mple an environry observating the ocalization states. ulti-ager	denvironments and algorial real-world as a settings. In the control of the contro	nents). They sarial agent gorithms for scenarios, a knowledge In addition, tial settings, his context, kov decision information. apping, and can explain in term of
Skills	Students can select an appropriate age scenarios. For simplified agent applica apply basic optimization techniques. Bayesian networks/dynamic Bayesian simple queries. Students can also nam simplified agent scenarios. For simple compute the best action or policies for students will apply techniques for f equilibria. For multi-agent decision reprotocols and compare and explain the	ation students of For those application networks and e and apply different concrete settionaling different making students.	can derive cations apply baseling basel	ve decisio they can ayesian re mpling teo making s multi-ager oria states	n trees and also created assoning for chairman for the ch
Personal Competence Social Competence	Students are able to discuss their communicate in English	solutions to	problem	s with o	thers. They
Autonomy	Students are able of checking their ur varaints of concrete problems	nderstanding of	complex	x concepts	s by solving
Workload in Hours	Independent Study Time 124, Study Ti	me in Lecture 5	<u> </u>		
Credit points	<u> </u>				
Course					

achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Blomodical Enginooring: Spocialication Implants and Endoprocthocos: Eloctivol

Course L0341: Inte	lligent Autonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	
CP	
	Independent Study Time 92, Study Time in Lecture 28
	Rainer Marrone
Language	
Cycle	
Сусіе	Wise
Content	 Definition of agents, rational behavior, goals, utilities, environment types Adversarial agent cooperation: Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance Uncertainty: Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning 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 Imp
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
	uides, Antennas, and Electromagnetic	Lecture	3	4
Compatibility (L1669)			_	7
Introduction to Wavego Compatibility (L1877)	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
Development and Regi	ulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in I		Seminar	2	3
Seminar Biomedical En	igineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00		Lecture	2	4
Ceramics Technology (L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended				
Previous				
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following Curricula	Piemodical Engineering Checiplication Management and Business Administration			

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

	Lecture
Hrs/wk	
СР	
	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and	
scale	
-	Prof. Christian Schuster
Language	
Cycle	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

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

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

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

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

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

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

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Ma	aterials (L1663)	Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
Introduction to Wavegui Compatibility (L1877)	ides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
	latory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods f	or the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in B	iomechanics (L1583)	Seminar	2	3
Seminar Biomedical Eng	gineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L000	1)	Lecture	2	4
Ceramics Technology (L	.0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached t	the following learn	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the Following Curricula	Riomodical Engineering: Specialisation Medical Technology and Central Theory			

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
	Lecture	
Hrs/wk		
СР		
	Independent Study Time 78, Study Time in Lecture 42	
Examination Form		
Examination duration and scale	30 min	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques	
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007) 	

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

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

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

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

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

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

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

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

Module M0746	6: Microsystem I	Engineering			
Courses					
Title Microsystem Engineering (L0680) Microsystem Engineering (L0682)			Typ Lecture Project-/problem-	Hrs/wk 2 2	CP 4
			based Learning		2
Admission Requirements	LNODE				
Recommended Previous Knowledge	Basic courses in physics, mathematics and electric engineering				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					(MEMS
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.				
Skills	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.				
Personal Competence		olvo sposifis probl	ome alono or in a g	roup and to	procent the
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.				
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with other fields.				
	Independent Study Time 124, Study Time in Lecture 56				
Credit points					
Course achievement	CompulsorBonus No 10 %	Form Presentation	Descrip	otion	
Examination	Written exam				
Examination duration and scale	2h				
	Electrical Engineering: Core qualification: Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: 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				
Assignment for the Following Curricula	Elective Compulsory	g: Specialisation Ang: Specialisation g: Specialisation	rtificial Organs and Implants and En Medical Technolog	Regenerative doprostheso	es: Elective

Elective Compulsory
Microelectronics and Microsystems: Core qualification: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective
Compulsory
Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
Flective Compulsory

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

Course L0682: Microsystem Engineering		
Тур	Project-/problem-based Learning	
Hrs/wk	2	
СР	2	
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28	
Lecturer	Prof. Manfred Kasper	
Language	EN	
Cycle	WiSe	
	Examples of MEMS components	
	Layout consideration	
Content	Electric, thermal and mechanical behaviour	
	Design aspects	
Literature	Wird in der Veranstaltung bekannt gegeben	

Module M075	L: Vibration Theory	
Courses		
Title Vibration Theory (L070	Typ Hrs/wk CP Integrated Lecture 4 6	
Module Responsible	Prof. Norbert Hoffmann	
Admission Requirements	None	
Recommended Previous Knowledge	Linear Algebra	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	them further.	
	Students are able to denote methods of Vibration Theory and develop them further.	
Personal Competence		
I	Students can reach working results also in groups.	
Autonomy	Students are able to approach individually research tasks in Vibration Theory.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points	6	
Course achievement	None	
Examination	Written exam	
	Examination duration and 2 Hours scale	
Assignment for the Following Curricula Curricula Curricula Energy Systems: Core qualification: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computational Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medical Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control The Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administrate Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Election Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Election Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Election Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Election Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Election Elective Compulsory		

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

Courses						
Title			Тур	Hrs/wk	СР	
Microsystems Technolo	ogy (L0724)		Lecture	2	4	
Microsystems Technolo	y (L0725) Project-/problem- based Learning 2 2					
Module Responsible	Prof. Hoc Khiem Trieu					
Admission Requirements	None					
Recommended Previous Knowledge	Basics in physics, chem	nistry, mechanics	and semiconductor	technology		
Educational Objectives	After taking part succes	ssfully, students	have reached the fo	llowing learr	ning results	
Professional						
Competence	Students are able					
		the fabrication				
Knowledge	 to explain in details operation principles of microsensors and microactual and to discuss the potential and limitation of microsystems in application. 					
Skills	 to analyze the feas to develop process to apply them. 		stems, prication of microstru	ictures and		
Personal Competence						
	Students are able to p well as to present and o				am work a	
Autonomy	None					
	Independent Study Tim	e 124, Study Tin	ne in Lecture 56			
Credit points						
	Compulsor B onus	Form	Descri Studier	-	ühren i	

Course achievement		no	ubject actical v	theoretic work		Laborprak Gruppe diskutiert Ergebniise vor dem g	präse die The e ihrer	entiert eorie sow Labortäti	
Examination	Oral exam								
Examination duration and scale	30 min								
Assignment for the Following Curricula	Electrical En Technology: El Electrical Engir Computational Robotics: Elect International M Compulsory Biomedical Eng Elective Compulsory Biomedical Englective Compulsory Biomedical Englective Compulsory Biomedical Englective Compulsory Biomedical Englective Compulsory	neering: Specific Science are ive Compuls lanagement gineering: Sulsory agineering: Sulsory gineering: Sulsory gineering: Sulsory	pulsory ecialisati nd Engir sory t and En specialisa Speciali Specialis	neering: S gineering ation Artif isation Ir sation Me	al Techno Specialisa : Speciali ficial Orga mplants edical Te	ation Systemation II. It is and Endochnology at and Bus	ems Er Mechatr egenera oprosth and Co siness A	ronics: Elective Medical Election The Control The Control The Control The Control The Control Election The Control	g and ective licine: ective neory:

Course L0724: Micr	osystems Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	
Cycle	WiSe
	 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, EpiPoly, 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

Content and GMR, fluxgate magnetometer) • Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal sensor; metal oxide semiconductor gas sensor, organic conductivity 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) M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009 Literature T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010

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

G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

Courses					
Title			Тур	Hrs/wk	СР
Finite Element Method	s (L0291)		Lecture	2	3
Finite Element Method	s (L0804)		Recitation (large)	Section 2	3
Module Responsible	Prof. Otto von Estorff				
Admission Requirements	None				
Recommended Previous Knowledge	Kinematics, Dynamics)	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 succes	sfully, students h	ave reached t	he following learr	ning results
Professional Competence					
Knowledge	The students possess a element method and ar basis of the method.				
Skills	The students are capal finite elements, assem resulting system of equ	bling the corresp			
Personal Competence					
Social Competence	Students can work in sn	nall groups on spe	ecific problem	s to arrive at joint	t solutions.
Autonomy	The students are able and develop own finite are critically scrutinized	element routines.			
Workload in Hours	I Independent Study Time	e 124, Study Time	e in Lecture 5	6	
Credit points	<u> </u>				
Course achievement	CompulsorFonus No 20 %	Form Midterm	D	escription	
Examination	Written exam				
Examination duration and scale					
	Civil Engineering: Core of Energy Systems: Core of Aircraft Systems Engine Aircraft Systems Engin	ualification: Electering: Specialisat	ive Compulso ion Aircraft Sy	stems: Elective C	Compulsory

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

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

Module M0814	4: Technology Manageme	ent		
Courses				
Courses		Tym	Uno/vuls	CD
Title Technology Manageme	ont (L0940)	Typ Project-/problem-	Hrs/wk 3	CP 3
		based Learning Project-/problem-		
Technology Manageme	ent Seminar (L0850)	based Learning	2	3
Module Responsible	IPINI UNINGHING HERGIAN			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business ma	nagement		
Educational Objectives		nts have reached the foll	lowing learn	ing results
Professional Competence				
Knowledge	 Technology Timing Strategies Technology Intelligence Technology Portfolio Manager Technology Portfolio M Technology Portfolio M Technology Acquisition IP Management Organizing Technology Devel Technology Organization Technology Funding & 	and Lifecycle Manageme e and Planning ment ethodology n and Exploitation opment on & Management	ent (I/II)	
Skills	 Develop an understanding of a national as well as internati Equip students with an under Management (strategic, or aspects) Foster a strategic oriental process as well as Technology strategy Clarify activities of Technology strateging activities of Technology strateging. Strengthen essential commanagerial, organizational Innovation- and R&D-manage Basic concepts, models a technology, R&D and innovation as a process (step 	onal level erstanding of important erstanding of important erstanding of important erstanding organizations tion to problem-solving y Management and its in logy Management (e.g., n) nunication skills and a leand financial issues comment. Further topics to be nd tools, relevant to ion	elements of al and pro within the mportance f technolog pasic under procerning To be discussed	Technology cess-related innovation or corporate y sourcing, estanding of echnology-, include:
Personal Competence				
Social Competence	Interact within a teamRaise awareness for globabl i	ssues		
Autonomy	Gain access to knowledge soInterpret complicated cases	urces		

	Develop presentation skills
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
_	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory

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

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

Module M0846	6: Control Systems The	ory and Desig	n	
Courses				
Title Control Systems Theor Control Systems Theor		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 4 2
Module Responsible	Prof. Herbert Werner	(Siliuli)		
Admission Requirements	None			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives	I ATTOR FAVING NART CHARGETHING CTIN	dents have reached	the following lear	ning results
Professional Competence				
Knowledge	 Students can explain how space models; they can in external excitation as trajec They can explain the syste their relationship to state fe They can explain the signifi They can explain observerachieve tracking and distur They can extend all of the active tracking and distur They can explain the z-t Transform They can explain state spacetime systems They can explain the expessystems, and how the idenormal equation They can explain how a discrete-time impulse response 	nterpret the system ctories in state space m properties controlled back and state escance of a minimal subased state feedback and state feedback and state rejection above to multi-input ransform and its recember and transform and transform trimental identification problem state space model	n response to inition response to inition response to inition respectively. The stimulation respectively and how it call multi-output systemationship with the fer function model on of ARX model can be solved	ervability, and tively in be used to tems the Laplace els of discrete by solving a
Skills	 Students can transform tranvice versa They can assess controllar realisations They can design LQG control They can carry out a control time domain, and decide with the can identify transfed dynamic systems from expensions. They can carry out all the Control Toolbox, System Identify 	ability and observa ollers for multivarial coller design both in hich is appropriate to r function models erimental data ese tasks using sta	bility and constole plants continuous-time for a given sampland state spacendard software	and discreteing rate e models o
Personal Competence				
Social Competence	ļ			
	Students can obtain information documentation, experiment guide			

Autonomy	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			
Course achievement	None		
Examination	Written exam		
Examination duration and scale	120 min		
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory Computational Science and Engineering: Specialisation Kernfächer Ingenieurswissenschaften (2 Kurse): Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation III. 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 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		

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

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

Courses				
		Тур	Hrs/wk	СР
Гhe Digital Enterprise ((L0932)	Lecture	2	2
Production Planning an		Lecture	2	2
Production Planning an	nd Control (L0930)	Recitation (small)	Section 1	1
Exercise: The Digital E	nterprise (L0933)	Recitation (small)	Section 1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of Production and Qu	ality Management		
Educational Objectives	After taking part successfully, stude	ents have reached	the following learr	ning results
Professional Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
Social Competence	Students can develop joint solutions	s in mixed teams a	and present them t	o others.
Autonomy	-			
Vorkload in Hours	Independent Study Time 96, Study Time in Lecture 84			
Credit points	6			
Course	None			
achievement	None			
Examination	Written exam			
Examination duration and scale	180 Minuten			
the Following	International Management and Engand Production: Elective Compulsor Logistics, Infrastructure and Mode Elective Compulsory Biomedical Engineering: Specialisate Elective Compulsory Biomedical Engineering: Specialisate Compulsory Biomedical Engineering: Specialisate Elective Compulsory Biomedical Engineering: Specialisate Elective Compulsory Biomedical Engineering: Specialisate Elective Compulsory Broduct Development, Material Development: Elective Compulsory Product Development, Materials Compulsory Product Development, Materials and Compulsory Theoretical Mechanical Engineeri	y polity: Specialisation political Organisation Implants a pation Medical Tect tion Management and Production and Production and Production: Sp	on Production and sand Regeneration and Endoprosthes thrology and Contant and Business Addion: Specialisation ecialisation Materians	d Logistic ve Medicine es: Electiv trol Theory ministratio on Produ Productio als: Electiv

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

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

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

Module M092:	1: Electronic Circuits for	Medical Applic	cations	
Courses				
Title Electronic Circuits for I	Medical Applications (L0696)	Typ Lecture	Hrs/wk	CP 3
Electronic Circuits for I	Medical Applications (L1056)	Recitation S (small)	Section 1	2
Electronic Circuits for I	Medical Applications (L1408)	Practical Course	1	1
itesponsible				
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical enginee	ring		
Educational Objectives	After taking part successfully, stude	ents have reached the	e following lear	ning results
Professional Competence				
Knowledge	 Students can explain the base central nervous system Students are able to explain propagation along an axon Students can exemplify the devices Students can describe the spapplications Students can explain the functions Students are able to discuss and artificial eyes 	communication betwo	an action pote een neurons a noise amplifier e. g. an artificia	ntial and indicate and electrons for medical hand
Skills	 Students can calculate the potential Students can give scenarios power signal acquisition. Students can develop the bl Students can define the buil eye. 	s for further improve	ment of low-no	oise and lov
Personal Competence				
Social Competence	 Students are trained to solv teams together with experts Students are able to recognifor assistance to the right tir Students can document their results in a way that others of 	with different professize their specific limit ne. ir work in a clear mar	sional backgrou ations, so that nner and comm	ind. they can as unicate the
	 Students are able to realisti define actions for improvement Students can break down 	ents when necessary.		

Autonomy	 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	
	CompulsorBonus Form Description	
Course achievement	No None Subject theoretical and practical work	
	No 20 % Excercises	
Examination	Oral exam	
Examination duration and scale	40 min	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	

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

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

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

Module M1150	0: Continuum Mechanics			
Courses				
Title Continuum Mechanics Continuum Mechanics		Typ Lecture Recitation	Hrs/wk 2 Section 2	CP 3
	, ,	(small)		
	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear continuum mechanics a (forces and moments, stress, linear constitutive laws, strain energy).			
Educational Objectives	After taking part successfully, students h	nave reached	the following learr	ning results
Professional Competence				
Knowledge	The students can explain the fundamental concepts to calculate the mechanical behavior of materials.			
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence Social Competence	The students are able to develop solutions, to present them to specialists in written form and to develop ideas further.			
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 5	6	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale	45 min			
Assignment for the Following	l <u>a</u> .	ng: Elective Co ement: Speci Course: Elect Artificial Organ	ompulsory alisation Materia tive Compulsory as and Regeneration	als: Elective ve Medicine: es: Elective

Curricula	Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Product Development, Materials and Production: Core qualification: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Module M1153	L: Material Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L15	35)	Lecture	2	3
Material Modeling (L15	36)	Recitation (small)	Section 2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous Knowledge	Basics of linear and nonlinear continu Mechanics II and Continuum Mechan nonlinear strain, free-body principle, energy)	nics (forces and	moments, stress	, linear and
Educational Objectives	After taking part successfully, student	s have reached	the following learn	ing results
Professional Competence				
Knowledge	The students can explain the fundam laws	entals of multidir	nensional consitut	tive material
Skills	The students can implement their c particular, the students can apply the science and evaluate the correspondi	eir knowledge to	various problems	
Personal Competence				
	The students are able to develop so	lutions, to prese	nt them to specia	alists and to
Social Competence	develop ideas further.			
Autonomy	The students are able to assess the independently and on their own ident modeling and acquire the knowledge	ify and solve pro	blems in the area	
Workload in Hours	 Independent Study Time 124, Study T	ime in Lecture 5	 6	
Credit points	<u> </u>	12 111 2000010 3	-	
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Computational Science and Engine Elective Compulsory Materials Science: Specialisation Mod Mechanical Engineering and Mana Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation Elective Compulsory	eling: Elective Co agement: Speci n Artificial Orgar ion Implants a	ompulsory alisation Materia as and Regenerativ nd Endoprosthese	ls: Elective ve Medicine: es: Elective

Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective Compulsory

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

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

Module M1199	9: Advanced Function	al Materials		
Courses				
Title Advanced Functional N	Materials (L1625)	Typ Lecture	Hrs/wk 2	CP 6
11000010101010	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge		ience, e.g. Materials Scier	nce I/II	
Educational Objectives	I ATTER TAKING NART SHCCESSTHINV ST	udents have reached the	following learn	ing results
Professional Competence				
Knowledge	The students will be able to exp their applications in techno semiconductor, modern compos	logy, in particular meta	allic, ceramic,	polymeric,
Skills	The students will be able to technical needs and, if necessar principles from the micro- to overview on modern materials materials combinations dependi	ry, to design new materia the macroscale. The s s science, which enables	ls considering a tudents will a s them to sele	architectural Iso gain an
Personal Competence				
Social Competence	The students are able to presfurther.	ent solutions to special	ists and to de	velop ideas
Autonomy	The students are able to assess their own strength gather new necessary ex			
Workload in Hours	Independent Study Time 152, S	tudy Time in Lecture 28		
Credit points				
Course achievement	None			
Examination				
Examination duration and scale	30 min			
Assignment for the Following Curricula	Blomedical Engineering: Specia	Management: Specialistical Organs a listing and large an	end Regenerative Endoprosthese Glogy and Cont d Business Adi	ve Medicine: es: Elective rol Theory: ministration:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Courses		
Title Introduction to Biocher	Typ Hrs/wk CP mistry and Molecular Biology (L0386) Lecture 2 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		
Knowledge	 describe basic biomolecules; explain how genetic information is coded in the DNA; explain the connection between DNA and proteins; 	
Skills	 The students can recognize the importance of molecular parameters for the course of a disease; describe selected molecular-diagnostic procedures; explain the relevance of these procedures for some diseases 	
Personal Competence		
Social Competence	The students can participate in discussions in research and medicine on a technical level.	
Autonomy	The students can develop understanding of topics from the course, using technical literature, by themselves.	
	Independent Study Time 62, Study Time in Lecture 28	
Credit points		
Course achievement	None	
Examination	Written exam	
Examination duration and scale		
	General Engineering Science (German program): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biomedica Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisatio Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisatio Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanica Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical	

Assignment for	Engineering: Compulsory
the Following	General Engineering Science (English program, 7 semester): Specialisation
Curricula	Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	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		
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Hans-Jürgen Kreienkamp	
Language	DE	
Cycle	WiSe	
Content		
	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage	
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008	
Literature		

Module M1333	3: BIO I: Implants a	and Fracture Heal	ling	
Courses				
Title Implants and Fracture	Healing (L0376)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to part "Implants and Fracture Hea		nto Anatomie" before	e attending
Educational Objectives	After taking part successfu	lly, students have reache	d the following learni	ng results
Professional Competence				
Knowledge	The students can describe for their existence. The students can name di given fracture morphologie	fferent treatments for the		
Skills	The students can determine static situations under spec		n the human body u	nder quasi-
Personal Competence				
Social Competence	The students can, in gr calculation of internal force		erical modeling tas	ks for the
Autonomy	The students can, in gr calculation of internal force		erical modeling tas	ks for the
Workload in Hours	Independent Study Time 6	2, Study Time in Lecture 2	28	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
	General Engineering Sc Engineering, Focus Biomed General Engineering Sc Engineering: Compulsory	hanics: Compulsory	·	
	General Engineering Sci Mechanical Engineering, Fo			ecialisation
	General Engineering Sci Biomedical Engineering: Co	ence (German program		ecialisation
	General Engineering So Engineering: Compulsory	ience (English prograi	•	Biomedical
Assignment for	General Engineering Sc Engineering, Focus Biomed	hanics: Compulsory	·	
the Following Curricula	General Engineering Sci Mechanical Engineering, Fo General Engineering Sci	ocus Biomechanics: Comp	oulsory	
	Biomedical Engineering: Co Mechanical Engineering: S _I Biomedical Engineering: S _I	ompulsory pecialisation Biomechanic	s: Compulsory	

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

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

Module M1334	4: BIO II: Biomaterials
Courses	
Title Biomaterials (L0593)	Typ Hrs/wk CP Lecture 2 3
	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.
Educational Objectives	
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.
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.
Personal Competence	
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Elective Compulsory

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2

	3 Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language			
Cycle			
	Topics to be covered include:		
	1. Introduction (Importance, nomenclature, relations)		
	2. Biological materials		
	2.1 Basics (components, testing methods)		
	2.2 Bone (composition, development, properties, influencing factors)		
	2.3 Cartilage (composition, development, structure, properties, influencing factors		
	2.4 Fluids (blood, synovial fluid)		
	3 Biological structures		
	3.1 Menisci of the knee joint		
	3.2 Intervertebral discs		
	3.3 Teeth		
	3.4 Ligaments		
	3.5 Tendons		
Content	3.6 Skin		
	3.7 Nervs		
	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptation of biological and technical materials (which are used for replacements in-vivo Acquisition of basics for theses work in the area of biomechanics.		
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRI Press, 1984.		
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Kee University, September 1978. New York: Wiley, 1998.		
Literature	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchi Livingstone, 1988.		
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.		
	[210]		

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berli Springer, 1996.	١,

Module M1342	2: Polymers			
Courses				
·	es of Polymers (L0389) with polymers (L1892)	Typ Lecture Lecture	Hrs/wk 2 2	CP 3 3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / mate	erial science		
Educational Objectives	After taking part successfully, stu	dents have reached the	e following learn	ing results
Professional Competence				
Competence	Students can use the knowledge analysis.	of plastics and define	the necessary	testing and
Knowledge	They can explain the complex rela	ationships structure-pro	perty relationsh	nip and
	the interactions of chemical structure of the polymers, including to explain neighboring contexts (e.g. sustainability, environmental protection).			
	Students are capable of			
Skills	- using standardized calculatio properties (modulus, strength) to			
	 selecting appropriate solution example stiffness, corrosion resis 		cling problems	and sizing
Personal	i i			
Competence	Students can			
	- arrive at funded work results in	heterogenius groups an	nd document the	em.
Social Competence	- provide appropriate feedback constructively.	and handle feedback	on their own p	performance
	Students are able to			
	- assess their own strengths and v	weaknesses.		
Autonomy	- assess their own state of learn steps on this basis.	ning in specific terms	and to define f	urther work
	- assess possible consequences o	f their professional activ	vity.	
	Independent Study Time 124, Stu	dy Time in Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and				

scale	
Assignment for the Following Curricula	Materials Science: Specialisation Engineering Materials: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation 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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

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

Module M0632: Regenerative Medicine							
Courses							
Title Regenerative Medicine Lecture Tissue Enginee	e (L0347) ering - Regenerative Med	dicine (L1664)	Typ Seminar Seminar	Hrs/wk 2 2	CP 3 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							
Knowledge	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells. The students can outline the actual concepts of Tissue Engineering and regenerative medicine and can explain the basic udnerlying principles of the discussed topics. After successful completion of the module students are						
Skills	 able to use medical databases for acquirierung and presentation of relevant up-to-date data independently able to present their work results in the form of presentations 						
Personal Competence Social Competence	Students are able to vand discuss their resustants are able to teachers.	ılts in the plenary a	nd to defend them	ı.			
Autonomy Workload in Hours	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. Independent Study Time 124, Study Time in Lecture 56						
Credit points		me 124, Study IIII	c iii Lecture 30				
Credit points		Earm	Deser	intion			
Course achievement	Yes 20 %	Form Written elaborat	ion Ausarl	ription peitung zu Rir pcol for lecture			
Examination	Presentation						

Examination duration and scale	Oral presentation + discussion (30 min)
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

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

Module M0548	8: Bioelectromagnetics:	Principles and	d Applicatio	ns
Courses				
_	Principles and Applications (L0371) Principles and Applications (L0373)	Typ Lecture Recitation (small)	Hrs/wk 3 Section 2	CP 5
Module Responsible	Prof. Christian Schuster	(ce.,		
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached t	he following learn	ing results
Professional Competence				
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.			
Skills	Students know how to apply var electromagnetic fields in biological make use of the elementary solu assess the most important effects they can order the effects corespectively, and they can analyzed evelop validation strategies for the effects of electromagnetic fields from the make an appropriate choice.	tissue. In order to o tions of Maxwell's that these models orresponding to v them in a quanti heir predictions. Th	do this they can r Equations. They predict for biolo wavelength and tative way. They ney are able to e	elate to and are able to gical tissue, frequency, are able to evaluate the
Personal Competence Social Competence				
Autonomy	Students are capable to gather publications and relate that informato make a connection between th content of other lectures (e.g. the electrical engineering / physics). The field of bioelectromagnetics in Engl	ation to the context eir knowledge obta eory of electromag ey can communicat	of the lecture. Thined in this lecture netic fields, fund	ney are able ure with the amentals of
Workload in Hours	Independent Study Time 110, Study	y Time in Lecture 70)	

Credit points	6			
	Compulsor B onus	Form	Description	
achievement	Yes 10 %	Presentation		
Examination	Oral exam			
Examination duration and scale	45 min			
the Following	Electromagnetic Compa Electrical Engineering: S International Manageme Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Theoretical Mechanical Compulsory	atibility: Elective Co Specialisation Medic ent and Engineering: Specialisation Art g: Specialisation g: Specialisation Mag: S	Microwave Engineering, mpulsory cal Technology: Elective Corg: Specialisation II. Electrical Grant and Regeneral Implants and Endoprosthe Indical Technology and Companies and Business And Complementary Cocialisation Bio- and Medical Cocialisation Bio- and Bio-	mpulsory al Engineering: ative Medicine: eses: Elective ontrol Theory: Administration: urse: Elective

Course L0371: Bioe	electromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	
	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics",
	CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
Literature	- 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: Bioe	electromagnetics: Principles and Applications		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	1		
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Christian Schuster		
Language			
Cycle			
	- Fundamental properties of electromagnetic fields (phenomena)		
	- Mathematical description of electromagnetic fields (Maxwell's Equations)		
	- Electromagnetic properties of biological tissue		
	- Principles of energy absorption in biological tissue, dosimetry		
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)		
	- Measurement techniques for characterization of electromagnetic fields		
Content	- Behavior of electromagnetic fields of low frequency in biological tissue		
	- Behavior of electromagnetic fields of medium frequency in biological tissue		
	- Behavior of electromagnetic fields of high frequency in biological tissue		
	- Behavior of electromagnetic fields of very high frequency in biological tissue		
	- Diagnostic applications of electromagnetic fields in medical technology		
	- Therapeutic applications of electromagnetic fields in medical technology		
	- The human body as a generator of electromagnetic fields		
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)		
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)		
Literature	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)		
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)		

Module M0630: Robotics and Navigation in Medicine					
Courses					
Title Robotics and Navigation Robotics and Navigation			Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Robotics and Navigation			Recitation Section (small)	n 1	1
Module Responsible	Prof. Alexander Schlae	fer			
Admission Requirements	INODE				
Recommended Previous Knowledge	 principles of pro 	gramming, e.g., in			
Educational Objectives	LATTER FARING NAME SHOOT	essfully, students h	ave reached the follo	wing learn	ing results
Professional Competence					
Knowledge	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.				
Skills	The students are abl systems for medical ap		evaluate navigation	systems	and robotic
Personal Competence					
Social Competence	The students discuss to incoorporate feedback	the results of othe into their work.	r groups, provide hel	pful feedb	ack and can
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tin	ne 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	1 8 0 5 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Form Written elaborati Presentation	Descript ion	cion	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Computer Science: Spe Electrical Engineering: Computational Scienc Robotics: Elective Com International Managen Elective Compulsory Mechatronics: Speciali Biomedical Engineerin Elective Compulsory Biomedical Engineerin	Specialisation Mede e and Engineering npulsory nent and Engineeri sation Intelligent S g: Specialisation A	dical Technology: Electical Technology: Electical Systems: Specialisation II. Systems and Robotics rtificial Organs and R	ctive Comp tems Engi Electrical I : Elective (Regenerative	oulsory neering and Engineering: Compulsory ve Medicine:

the Following	Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
Curricula	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 The analysis of Machaniae L. Franka and Tachnical Compulsors
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

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

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

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

Module M0634	4: Introduction i	nto Medical	Technology an	d Syste	ems
Courses					
Courses			_	, .	
	cal Technology and Systen cal Technology and Systen		Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Introduction into Medic	cal Technology and Systen	ns (L1876)	Recitation Section (large)	1	1
Module Responsible	i Prof. Alexander Schlaet	er			
Admission Requirements	None				
Recommended Previous Knowledge	principles of stochastic	CS .	ulus)		
Educational Objectives	After taking part succes	ssfully, students h	ave reached the follow	wing learni	ing results
Professional Competence					
Knowledge	The students can exp systems, computer aid to give an overview of i	ed surgery, and m	nedical information sy	stems. Th	ey are able
Skills	The students are able clinical applications.	to evaluate syste	ms and medical dev	ices in the	e context of
Personal Competence					
Social Competence	The students describe tasks that are solved in		dical technology as	a project,	and define
Autonomy	The students can refle They can present the re			results of	their work.
Workload in Hours	Independent Study Tim	e 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	CompulsorBonus Yes 10 % Yes 10 %	Form Written elaborati Presentation	Descript ion	ion	
Examination	Written exam				
Examination duration and scale	90 minutes				
Assignment for the Following	General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computer Science: Sp Compulsory Electrical Engineering: General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computational Science Elective Compulsory	ry Science (Germany: Compulsory Decialisation Compulsory Core qualification: Science (Englistry Science (Englishy: Compulsory	outer and Software Elective Compulsory h program): Speci	ester): Sp Engineering Malisation Mester): Sp	pecialisation ng: Elective Biomedical pecialisation
	•				

Curricula	Computational Science and Engineering: Specialisation Computer Science: Elective
	Compulsory
	Computational Science and Engineering: Specialisation Mathematics & Engineering
	Science: 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
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

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

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

Module M0752	2: Nonlinear Dynamics	
Courses		
Title Nonlinear Dynamics (L	Typ Hrs/wk CP .0702) Integrated Lecture 4 6	
Module Responsible	Prof. Norbert Hoffmann	
Admission Requirements		
Recommended Previous Knowledge	Linear Algebra	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	to develop and research new terms and concepts.	
Skills	Dynamics and to develop novel methods and procedures.	
Personal Competence		
•	Students can reach working results also in groups. Students are able to approach given research tasks individually and to identify and	
Autonomy Workload in Hours	follow up novel research tasks by themselves. Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement	None	
	Written exam	
Examination duration and scale	2 Hours	
Assignment for the Following Curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory	

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

Courses				
Title Semiconductor Techno	Jagy (10722)	Typ Lecture	Hrs/wk 4	CP 4
Semiconductor Techno	= -	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	y, students have reached the fo	llowing learn	ing results
Professional Competence				
Knowledge	substrates,to discuss in details th	explain current fabrication tech e relevant fabrication processe cation of semiconductor device rocess flows.	s, process fl	ows and th
Skills	to select and to evaluate	f process parameters on the pro e processes and s for the fabrication of semicond	_	
Personal Competence				
Social Competence		re and perform their lab expenses the results in front of audience		eam work
Autonomy	None			
	Independent Study Time 96,	Study Time in Lecture 84		
Credit points				
Course achievement	None			
Examination	Oral exam			
	<u> </u>			

duration and scale	
Assignment for the Following Curricula	Compulsory Riomodical Engineering: Specialisation Modical Technology and Control Theory:

I	Liective Compuisory
Course L0722: Sem	niconductor Technology
	Lecture
Hrs/wk	
CP	
	Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and GaAs: impurities, purification, Czochralski , Bridgeman and float zone process) Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, higher order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation damage, annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinetics, influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation of GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kinetics, temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques: APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuum evaporation, sputtering) Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximity and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique and electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electron beam lithography, X-ray 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, io

	chip-on-board, chip assembly, electrical contact: wire bonding, TAB and flip chip, wafer level package, 3D stacking)
	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
Literature	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M083!	5։ Hu	ımano	id Rob	otics					
Courses									
Title Humanoid Robotics (LC	0663)					Typ Seminar		Hrs/wk 2	CP 2
Module Responsible	Patric	k Göttsch	١						
Admission Requirements	None								
Recommended Previous Knowledge	•		tion to cor theory and						
Educational Objectives		taking pa	rt success	fully, stu	udents h	ave reached	the follo	wing learn	ing results
Professional Competence									
Knowledge	_					bots. rol concepts	for differ	ent tasks	in humanoic
Skills	•	based o	n specified s generaliz	d literatu ze devel	ure loped res	ut selected sults and pre give a preser	sent ther		
Personal Competence									
Social Competence		present They ar	them	provid	de appro	ng solutions opriate feedl			
Autonomy		presenta Studenta	ation for sp s familiarizow presen	pecific to ze them:	asks and selves w	and drawk I select the b vith a scientif students, su	est soluti ic field, a	ion are able of	introduce it
Workload in Hours	!	endent S	tudy Time	32, Stu	dy Time	in Lecture 28	8		
Credit points									
Course achievement	<u> </u>								
Examination Examination duration and scale	30 mi								
	Electr Comp Mecha Mecha Biome	oulsory atronics: atronics:	Specialisa gineering:	tion Inte	elligent S tem Des	Control ar systems and ign: Elective artificial Orga	Robotics: Compuls	Elective (Compulsory

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

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

Courses				
Title Linear and Nonlinear S	system Identification (L0660)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Discrete-time systems 	alue decomposition		
Educational Objectives	I Aftar taking nart cliccaectiilly eti	udents have reached th	e following learn	ing results
Professional Competence				
Knowledge	 Students can explain the and its application to a va They can explain how monlinear dynamics They can explain how a based on neural network of they can explain the idea realisation theory 	riety of linear and nonlinultilayer perceptron nonlinultilayer perceptron nonlinultilayer predict models	near model struce etworks are use ive control sche	ctures ed to mode eme can be
Skills	 Students are capable of experimental identification systems They are capable of implemental network They are capable of application of linear modern capable of application capable of ap	on of linear and nonlocation of linear and nonlocation of linear k model oplying subspace algor dels for dynamic system ising standard software	inear models for predictive con ithms to the east	for dynami trol scheme experimenta
Personal Competence				
Social Competence	Students can work in mixed grou	ups on specific problems	to arrive at join	t solutions.
Autonomy	Students are able to find requir literature, software documentation			cture notes
Workload in Hours	IIndependent Study Time 62, Stu	dy Time in Lecture 28		
Credit points				
Course achievement	None			
Examination	Oral exam			
Examination duration and scale				
	Electrical Engineering: Specia Compulsory Mechatronics: Specialisation Inte	lisation Control and elligent Systems and Rol	-	

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

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

Courses				
Title Optimal and Robust Co		Typ Lecture Recitation	Hrs/wk 2 Section 2	CP 3
		(small)		3
поорононо				
Admission Requirements				
Recommended Previous Knowledge	 State space methods 		5)	
Educational Objectives	LATTER TAKING NART CHCCECCTIIIIV G	students have reached t	:he following learr	ning results
Professional Competence				
Knowledge	 Students can explain the solution of LQ problems. They can explain the distate estimation. They can explain how stability and performance. They can explain how a case of an H2 design provides itself to robust contract they can explain how a lends itself to robust contract they can explain how a can guarantee stability at they understand how a can be represented as limited. 	the H2 and H-infinity to constraints. In LQG design problem oblem. In model uncertainty can arroller design based on the small gair and performance for an analysis and synthesis	I state feedback norms are used to can be formulate be represented in theorem - a robuuncertain plant. conditions on fee	and optime to represe ed as speci n a way the ust controll
Skills	 Students are capable multivariable plant mode They are capable of reform of a generalized plant. They are capable of transcontrol loops into conscarrying out a mixed-ser They are capable of consystem, and of designing They are capable of for matrix inequalities (LMI) They can carry out all robust control toolbox). 	els. presenting a H2 or H-i lant, and of using stand nslating time and frequentraints on closed-loop nsitivity design. nstructing an LFT uncer g a mixed-objective robi mulating analysis and , and of using standard	nfinity design prolated software tool ency domain specton sensitivity function tainty model for a sust controller, synthesis condition LMI-solvers for so	oblem in the last for solving ifications for solving an uncertains as line oblining them
Personal Competence				
	Students can work in small gro		-	
Autonomy	Students are able to find requ literature, software documenta			ecture note

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory 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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

itle larketing of Innovation BL Marketing of Innova		Typ Lecture Project-/problem- based Learning	Hrs/wk 4 1	CP 4 2
Module	Prof. Christian Lüthje	buseu Leuming		
Responsible	None			
Recommended Previous Knowledge	 decision theory, project n Bachelor-level Marketing Competitor Strategies, Ba Unerstanding the differer 	usiness administration princi nanagement, international bo Knowledge (Marketing In- asics of Buying Behavior) nces beweetn B2B and B2C noortance of managing innova	usiness) struments, narketing	Market ar
Educational Objectives	After taking part successfully, st	tudents have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	 Approaches for analyzing development The gathering of informat Concepts and approach product and service deve Approaches and tools for of new products and inno Marketing mix element requirements and challen Pricing methods for new products of comp 	the marketing of innovative the current market situation tion about future customer n es to integrate lead users elopment processes r ensuring customer-orientativative services of that take into consinges of innovative products a	n and the fureeds and restand their ion in the dideration to the selling	uture mark quirements needs in levelopmen he specif
Skills	strategies Analyze markets by apply Conduct forecasts and deplanning Translate customer need and successfully apply acservice development Use adequate methods to services Choose suitable pricing innovations	ge students will be able to: e decisions regarding manying market and technology pevelop compelling scenarios dis into concepts, prototypes divanced methods for custom of foster efficient diffusion of g strategies and communicisions for products and se	oortfolios as a basis and marke er-oriented innovative p	for strateg table offer product ar products ar ctivities f

Competence	
	The students will be able to
Social Competence	 have fruitful discussions and exchange arguments develop original results in a group present results in a clear and concise way carry out respectful team work
Autonomy	 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	
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine:

Course L2009: Mar	keting of Innovations
Тур	Lecture
Hrs/wk	
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	
Cycle	
	 Introduction Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)
	II. Methods and approaches of strategic marketing planning
	 patterns of industrial development, patent and technology portfolios
	III. Strategic foresight and scenario analysis
	 objectives and challenges of strategic foresight, scenario analysis, Delphi method
	IV. User innovations
Content	 Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	 Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	 Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	 Diffusion of Innovations, Communication Objectives, Communication Instruments
	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
Literature	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press
	13

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

Module M1143	3: Mechanical Design Metho	dology		
Courses				
Title Mechanical Design Me Mechanical Design Me		Typ Lecture Recitation (small)	Hrs/wk 3 Section 1	CP 4 2
Module Responsible	Prof. Josef Schlattmann	(Siliali)		
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students l	nave reached t	he following learn	ing results
Professional Competence	Science-based working on product d	esign consider	ring targeted ar	pplication o
	specific product design techniques Creative handling of processes used for scientific preparation and formulation o complex product design problems / Application of various product design techniques following theoretical aspects.			
Personal Competence Social Competence				
Autonomy Workload in Hours	Independent Study Time 124, Study Tim	ne in Lecture 56	 ;	
Credit points Course				
achievement	none			
Examination Examination duration and scale				
Assignment for the Following Curricula	Product Dovolopment Materials s	sign: Elective C Artificial Organs In Implants an Medical Tech Management and Production oduction: Specialisation	compulsory is and Regenerative and Endoprosthese nology and Confe and Business Add on: Specialisation ialisation Product cialisation Materi Product Develo	ve Medicine es: Elective trol Theory ministration on Product ion: Elective als: Elective

Compulsory

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

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

Module M0938	8: Bioprocess Engineering -	Fundamentals		
Courses				
Title		Тур	Hrs/wk	СР
	g - Fundamentals (L0841)	Lecture	2	3
Bioprocess Engineering	g- Fundamentals (L0842)	Recitation Section (large)	12	1
Bioprocess Engineering	g - Fundamental Practical Course (L0843)	Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements				
Knowledge	none, module "organic chemistry", modu			
Educational Objectives	After taking part successfully, students h	nave reached the follo	wing learn	ing results
Professional Competence				
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.			
Skills	After successful completion of this modu describe different kinetic approace calculate the corresponding parar predict qualitatively the influen redox equivalents and growth inh analyze bioprocesses on basis metabolic flux equations distinguish between scale-up bioprocesses (anaerobic, aerobic as well as to apply them to currer propose solutions to complicated the corresponding models to explore new knowledge resource identify scientific problems with solutions. to document and discuss their properties.	thes for growth and sumeters ce of energy general ibition on the ferment of stoichiometry an criteria for differe as well as microaero at biotechnical problem dibiotechnological process ces and to apply the n concrete industrial	ation, regeration proceed to set biore bic) to consider and the biore bi	eneration of ess up / solver actors and mpare then do deduced to deduced to formulate to formulate endiced contents to formulate endiced contents and the endiced contents
Personal Competence Social Competence	After completion of this module partic questions in small teams to enhance opinions and increase their capacity fenvironments.	the ability to take or teamwork in engi	position to neering a	o their own
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		

Credit points	6
Course achievement	Cubiast theoretical and
Examination	Written exam
Examination duration and scale	90 min
	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Bioprocess Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

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

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

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

Module M1277	7: MED I: Introduction to Anatomy
Courses	
Title Introduction to Anatom	Typ Hrs/wk CP ny (L0384) Lecture 2 3
	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	
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system. The students can describe the basic macroscopy and microscopy of those systems.
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explain the relevance of structures and their functions in the context of widespread diseases.
Personal Competence	
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	
Course achievement	None
	Written exam
Examination duration and scale	
	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	Electrical Engineering, Focus Biomechanics. Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
Accianment for	General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory
the Following	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory

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

Course L0384: Introduction to Anatomy					
Тур	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Lecturer	Prof. Tobias Lange	Prof. Tobias Lange			
Language	DE	DE			
Cycle	SoSe	SoSe			
	General Anatomy				
	1 st week:	The Eucaryote Cell			
	2 nd week:	The Tissues			
	3 rd week:	Cell Cycle, Basics in Development			
	4 th week:	Musculoskeletal System			
	5 th week:	Cardiovascular System			
	6 th week:	Respiratory System			
Contont	7 th week:	Genito-urinary System			
Content	8 th week:	Immune system			
	9 th week:	Digestive System I			
	10 th week:	Digestive System II			
	11 th week:	Endocrine System			
	12 th week:	Nervous System			
	13 th week:	Exam			
Literature		l Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag			

Module M127 Therapy	78: MED I: Introduction to Radiology and Radiation			
Courses				
Title Introduction to Radiolo	Typ Hrs/wk CP ogy and Radiation Therapy (L0383) Lecture 2 3			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy. The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine). The students can describe the patients' passage from their initial admittance through to follow-up care. Diagnostics The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US). The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques. The students can choose the right treatment method depending on the patient's clinical history and needs. The student can explain the influence of technical errors on the imaging techniques. The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.			
Skills	The students can distinguish curative and palliative situations and motivate why they came to that conclusion. The students can develop adequate therapy concepts and relate it to the radiation biological aspects. The students can use the therapeutic principle (effects vs adverse effects) The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).			
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).			
	Diagnostics			

	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.			
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.			
Personal Competence				
	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.			
	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.			
Autonomy	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	INDDA			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory General Engineering: Science (English program, 7 semester): Specialisation Biomedical Engineering: Specialisation Biomechanics: 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			

Course L0383: Introduction to Radiology and Radiation Therapy		
Тур	Lecture	
Hrs/wk	2	
СР	3	

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

Module M1280	0: MED II: Introduction to Physiology			
Courses				
Title Introduction to Physiol	Typ Hrs/wk CP logy (L0385) Lecture 2 3			
Module Responsible	Dr. Roger Zimmermann			
Admission Requirements	None			
Recommended Previous	None			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	 The students can describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. 			
Skills	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				
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.			
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	INONE			
Examination	Written exam			
Examination duration and scale	60 minutes			
scale	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory			
	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory			
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation			
	Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical			
Assianment for	Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory			
the Following	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory			
	General Engineering Science (English program, 7 semester): Specialisation			

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

Module M1332	2: BIO I: Experimental	Methods in Biom	nechanics	
Courses				
Title Experimental Methods	in Biomechanics (L0377)	Typ Lecture	Hrs/wk CP 2 3	
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to partici attending "Experimentelle Metho		nd Frakturheilung" before	
Educational Objectives	After taking part successfully, st	udents have reached the	e following learning results	
Professional Competence				
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under given fracture morphologies.			
	The students can describe dimovements, and choose the add		-	
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.			
Personal Competence				
Social Competence	The students can, in groups, solv	ve basic experimental ta	sks.	
Autonomy	The students can, in groups, sol	ve basic experimental ta	sks.	
	Independent Study Time 62, Stu	dy Time in Lecture 28		
Credit points				
Course achievement	none			
Examination Examination duration and scale				
	General Engineering Science Engineering, Focus Biomechanic General Engineering Science Engineering: Compulsory General Engineering Science Mechanical Engineering, Focus E General Engineering Science Biomedical Engineering: Compul General Engineering Science Engineering: Compulsory General Engineering Science	ss: Compulsory (German program): (German program, 7 Biomechanics: Compulsor (German program, 7 Isory (English program):	Specialisation Biomedical semester): Specialisation ry semester): Specialisation Specialisation Biomedical	
tne Following	Engineering, Focus Biomechanic General Engineering Science Mechanical Engineering, Focus E General Engineering Science Biomedical Engineering: Comput Mechanical Engineering: Special	(English program, 7 Biomechanics: Compulso (English program, 7 Isory	ry semester): Specialisation	

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

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

Module M1335	5: BIO II: Artificial Joint	: Replacement		
Courses				
Title Artificial Joint Replacer	ment (L1306)	Typ Lecture	Hrs/wk 2	CP 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic a	nd surgical techniques is rec	ommended	
Educational Objectives	After taking part successfully, stu	udents have reached the foll	owing learn	ing results
Professional Competence				
Knowledge	The students can name the different kinds of artificial limbs.			
Skills	The students can explain the advantages and disadvantages of different kinds of endoprotheses.			
Personal Competence				
Social Competence	The students are able to discuss and the teachers.	issues related to endoproth	ese with stu	ıdent mates
Autonomy	The students are able to acquire information with respect to its cr		hey can als	so judge the
Workload in Hours	Independent Study Time 62, Stud	dy Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	Blomedical Engineering: Specialisation Medical lechnology and Control Theory:			

Course L1306: Arti	ficial Joint Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	
Content	 Inhalt (deutsch) EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren) DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz) TIE HAND (Anatomie, Biomechanik, Ge-lenkersatz) 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	5: Feedback Control in	Medical Techno	logy
Courses			
Title Feedback Control in Mo	edical Technology (L0664)	Typ Lecture	Hrs/wk CP 2 3
Module Responsible	Johannes Kreuzer		
Admission Requirements	None		
Recommended Previous Knowledge	Basics in Control, Basics in Physic	logy	
Educational Objectives	After taking part successfully, stu	dents have reached the	e following learning results
Professional Competence			
	The lecture will introduce into the engineering point of view. Fundintroduced like knowledge in cont	lamentals in human p	
Knowledge	Internal control loops of the humadesign of external closed loop sys		
	The handling of PID controllers a fuzzy controller or neural netwood equivalent circuits will be discuss	orks will be illustrated	
Skills	Application of modeling, identific technology.	cation, control technol	ogy in the field of medical
Personal Competence			
Social Competence	Students can develop solutions their results (e.g. during project w	to specific problems ir veek)	small groups and present
Autonomy	Students are able to find necess lecture. They are able to continuous of their learning process. They of form a consistent whole.	ously evaluate their kno	owledge and to take control
Workload in Hours	Independent Study Time 62, Stud	y Time in Lecture 28	
Credit points	3		
Course achievement	none		
Examination	Oral exam		
Examination duration and scale	20 min		
Assignment for the Following Curricula	Elective Compulsory	sation Control and lisation Implants and sation Artificial Organs	Power Systems: Elective Endoprostheses: Elective and Regenerative Medicine:

Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory

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

Courses				
Title Advanced Topics in Co	ntrol (10661)	Typ Lecture	Hrs/wk 2	CP 3
Advanced Topics in Co		Recitation	Section 2	3
Advanced Topics in Co	TILIOT (LOUGZ)	(small)	2	
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-se	ensitivity design, line	ear matrix inequal	ities
Educational Objectives	After taking part successfully, stud	ents have reached t	he following learn	ing results
Professional				
Competence				
	 Students can explain the ac scheduling approach They can explain the represe LPV systems They can explain how stabic can be formulated as LMI co They can explain how gridd synthesis problems for LPV seen explain with polytosome of the basic synthesis structures 	entation of nonlinea lity and performanc nditions ing techniques can l systems opic and LFT repres	r systems in the for the conditions for the conditions for the conditions of LPV seems and the conditions of LPV seems are conditions of LPV seems are conditions.	orm of quas PV systems analysis and
Knowledge	 Students can explain how green communication topology of the comprotocols They can explain the comprotocols They can explain analysis are involving either LTI or LPV are students can explain the students can explain the students can explain (in outline such distributed systems) 	multiagent systems vergence propertie nd synthesis conditions gent models state space represe discretized according) the extension of	s of first order ons for formation of ntation of spatia ng to an actuator/ the bounded rea	r consensus control loop Ily invarian sensor arrasal lemma to
Skills	 Students are capable of controllers Students are capable of controllers Students are capable of controllers They are able to use standary for these tasks 	onstructing LPV mo y design of gain-sc or general LPV mode ard software tools (N	dels of nonlinear heduled controlle els Matlab robust con tion controllers fo	plants and rs; they car trol toolbox

	 Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

Specialization Medical Technology and Control Theory

Module M0623	3: Intelligent	t Systems i	n Medicine		
Courses					
Title Intelligent Systems in Intelligent Systems in Intelligent Systems in	Medicine (L0334)		Typ Lecture Project Sem Recitation (small)	Hrs/wk 2 inar 2 Section 1	CP 3 2
Module Responsible	Prof. Alexander S	chlaefer			
Admission Requirements	None				
Recommended Previous Knowledge	principlesprinciples	of stochastics	, analysis/calculus) Java/C++ and R/Maills	atlab	
Educational Objectives		successfully, stu	dents have reached	l the following learr	ning results
Professional Competence					
Knowledge	support problems able to explain disadvantages in representing me clinical data and	s using methods methods for cla clinical contexts dical knowledge d explain challer	and solve clinical to s for search, optimi assification and the s. The students can e. They can evaluanges due to the clir d safety requiremen	zation, and planning it respective advactoring advactoring to the compare different ite methods in the nical nature of the	ng. They are antages and methods fo e context o
Skills		orediction. They	r selecting and adap can assess the me ed methods.		
Personal Competence					
Social Competence			of other groups, provork.	ovide helpful feedb	ack and car
Autonomy			nowledge and docu n appropriate mann		f their work
Workload in Hours	Independent Stud	dy Time 110, Stu	dy Time in Lecture	70	
Credit points	6				
Course achievement	1 Y 🗠 C = 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Written e	laboration	Description	
Examination	Written exam				
Examination duration and scale	90 minutes				
	Electrical Engine	ering: Specialisat	Intelligence Engine tion Medical Techno ineering: Specialisa	logy: Elective Comp	pulsory

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

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

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

Module M0629	9: Intelligent Autonomous Agents and Cognitive Robotics
Courses	
_	Typ Hrs/wk CP s Agents and Cognitive Robotics (L0341) s Agents and Cognitive Robotics (L0512) Recitation Section 2 2 Recitation (small)
Module Responsible	Rainer Marrone
Admission Requirements	
Knowledge	Vectors, matrices, Calculus
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.
Skills	Students can select an appropriate 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	
Social Competence	Students are able to discuss their solutions to problems with others. They communicate in English
Autonomy	Students are able of checking their understanding of complex concepts by solving varaints of concrete problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course	

achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory

Course L0341: Inte	lligent Autonomous Agents and Cognitive Robotics	
Тур	Lecture	
Hrs/wk	2	
СР	4	
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28	
Lecturer	Rainer Marrone	
Language	EN	
Cycle	WiSe	
Content	 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 join probability distribution, marginalization, summing out, answering queries complexity, independence assumptions, naive Bayes, conditional independence assumptions Bayesian networks: Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived). Probabilistic reasoning over time: Environmental state may change even without the agent performing actions dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations Decision making under uncertainty: Simple decisions: utility theory, multivariate utility functions, dominance decision networks, value of informatio Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks Simultaneous Localization and Mapping Planning 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	
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Pete Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005 Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009 	

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
Introduction to Waveg Compatibility (L1877)	uides, Antennas, and Electromagnetic	Recitation (small)	Section 2	2
	ulatory Approval of Implants (L1588)	Lecture	2	3
Experimental Methods	for the Characterization of Materials (L1580)	Lecture	2	3
Numerical Methods in	Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Er	ngineering (L1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L00	01)	Lecture	2	4
Ceramics Technology	(L0379)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission	Name			
Requirements	None			
Recommended				
Previous				
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached	the following learn	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the Following Curricula	g Elective Compulsory			

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility		
Тур	Lecture	
Hrs/wk		
СР		
	Independent Study Time 78, Study Time in Lecture 42	
Examination Form		
Examination duration and scale	30 min	
Lecturer	Prof. Christian Schuster	
Language	DE/EN	
Cycle	WiSe	
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques	
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007) 	

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

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

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

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

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

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

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

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

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

Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
Introduction to Waveguides, Antenna. Compatibility (L1877)	s, and Electromagnetic	Recitation (small)	Section 2	2
Development and Regulatory Approve	al of Implants (L1588)	Lecture	2	3
Experimental Methods for the Charac	-	Lecture	2	3
Numerical Methods in Biomechanics (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L18	90)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Morlock			
Admission Requirements				
Recommended Previous Knowledge				
Educational Objectives	part successfully, students h	ave reached	the following learr	ing results
Professional				
Competence				
Knowledge				
Skills				
Personal				
Competence				
Social Competence				
Autonomy				
Workload in Hours Depends on o	choice of courses			
Credit points 12				
Assignment for the Following Curricula Elective Compulsory Elective Compulsory Elective Com	Engineering: Specialisation Engineering: Specialisation pulsory Engineering: Specialisation l	Implants a	nd Endoprosthes	es: Elective

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

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Тур	Lecture
Hrs/wk	3
СР	4
	Independent Study Time 78, Study Time in Lecture 42
Examination Form	
Examination duration and scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	WiSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC) for graduate engineering students that do not have a formal background in electrical engineering. It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	 - Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

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

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

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

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

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

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

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

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

Module M0746	6: Microsystem	Engineering					
Courses							
Title Microsystem Engineering (L0680)			Typ Lecture Project-/problem-	Hrs/wk	CP 4		
Microsystem Engineeri	ing (L0682)		based Learning	2	2		
	!	Prof. Manfred Kasper					
Admission Requirements	LNODE						
Knowledge	Basic courses in physic			_			
Educational Objectives	After taking part succe	essfully, students h	ave reached the fol	lowing learn	ing results		
Professional Competence					£145146		
Knowledge	The students know abo well as their applicatio	ns in sensors and	actuators.				
Skills	Students are able to components and to ever			nal behaviou	ur of MEMS		
Personal Competence							
Social Competence	results accordingly.	Students are able to solve specific problems alone or in a group and to present the results accordingly.					
Autonomy	Students are able to ac integrate and associate			cialized liter	ature and to		
	Independent Study Tin	ne 124, Study Tim	e in Lecture 56				
Credit points	! !						
Course achievement	CompulsorBonus No 10 %	Form Presentation	Descri	ption			
Examination	Written exam						
Examination duration and scale	2h						
	Electrical Engineering: Core qualification: Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: 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						
Assignment for the Following Curricula	Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Biomedical Engineering Elective Compulsory	ompulsory lechatronics: Specialisation System Design: Elective Compulsory iomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: lective Compulsory iomedical Engineering: Specialisation Implants and Endoprostheses: Elective ompulsory iomedical Engineering: Specialisation Medical Technology and Control Theory:					

Elective Cor						
Microelectro	nics and Mic	crosystems: Co	ore qualifica	ation: Elective Co	mpulsory	
Theoretical	Mechanical	Engineering:	Technical	Complementary	Course:	Elective
Compulsory						
Theoretical	Mechanical	Engineering:	Specialisat	ion Bio- and Me	dical Tec	hnology:
Flective Con	nnulsory		•			0,1

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

Course L0682: Mici	Course L0682: Microsystem Engineering		
Тур	Typ Project-/problem-based Learning		
Hrs/wk	2		
СР	2		
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28		
Lecturer	Prof. Manfred Kasper		
Language	EN		
Cycle	WiSe		
	Examples of MEMS components		
	Layout consideration		
Content	Electric, thermal and mechanical behaviour		
	Design aspects		
Literature	Wird in der Veranstaltung bekannt gegeben		

Module M075	L: Vibration Theory
Courses	
Title Vibration Theory (L070	Typ Hrs/wk CP Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	tnem furtner.
SKIIIS Personal	Students are able to denote methods of Vibration Theory and develop them further.
Competence	
•	Students can reach working results also in groups.
· ·	Students are able to approach individually research tasks in Vibration Theory.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	
Assignment for the Following Curricula	Energy Systems: Core qualification: Elective Compulsory Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: 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: Technical Complementary Course: Elective Compulsory

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

Courses					
Title			Тур	Hrs/wk	СР
Microsystems Technolo	ogy (L0724)		Lecture	2	4
Microsystems Technolo	ogy (L0725)		Project-/problem- based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu				
Admission Requirements	None				
Recommended Previous Knowledge		mistry, mecha	nics and semiconductor	technology	
Educational Objectives	LATTER TAKING DART SUCC	essfully, stude	nts have reached the fo	llowing learr	ning results
Professional		-			
Competence	Students are able				
	 to present and to explain current fabrication techniques for microstructures are especially methods for the fabrication of microsensors and microactuators, as we as the integration thereof in more complex systems 				
Knowledge	to explain in details operation principles of microsensors and microac and				
	to discuss the pot	tential and limi	tation of microsystems	in applicatio	n.
	Students are capable				
	to analyze the feat	asibility of micr	osystems,		
	to develop proces	ss flows for the	fabrication of microstr	uctures and	
Skills	to apply them.				
Personal Competence					
Social Competence			perform their lab expensesults in front of audience		eam work
Autonomy	None				
	Independent Study Ti	me 124, Study	Time in Lecture 56		
Credit points					
	Compulsor B onus	Form	Descr i Studie	-	ühren

Course achievement		NIANA	Subject practical		al and	Laborpral Gruppe diskutiert Ergebniis vor dem (präse die The e ihrer	entiert eorie sow Labortäti	
Examination	Oral exam								
Examination duration and scale	30 min								
Assignment for the Following Curricula	Electrical Er Computatio Robotics: El Internationa Compulsory Biomedical Elective Cor Biomedical Compulsory Biomedical Elective Cor Biomedical Elective Cor	Engineering: mpulsory Engineering Engineering mpulsory Engineering:	mpulsory pecialisat and Engi ulsory nt and Er Specialis : Specialis : Specialis	neering: Some of the serion of	al Techno Specialis : Special ficial Org mplants edical Te	ation Systemation II. Jans and R and End echnology nt and Bu	Mechat Mechat egenera oprosth and C siness	ngineerin ronics: El ative Med eses: El ontrol Tr Administr	g and ective dicine: ective neory:

	, , , , , , , , , , , , , , , , , , , ,
Course L0724: Micr	osystems Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
	 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

Content

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)

M. Madou: Fundamentals of Microfabrication, CRC Press, 2002

N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009

Literature

T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010

G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

Module M0814	1: Technology Manageme	nt		
Courses				
Title		Тур	Hrs/wk	СР
Technology Manageme	ent (L0849)	Project-/problem-	3	3
Technology Manageme		based Learning Project-/problem- based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous Knowledge	Bachelor knowledge in business mar	nagement		
	After taking part successfully, studer	nts have reached the fol	lowing learn	ning results
Professional Competence				
Knowledge	 Technology Timing Strategies Technology Strategies Technology Intelligence Technology Portfolio Managen Technology Portfolio Me Technology Portfolio Me Technology Acquisition IP Management Organizing Technology Develoge Technology Funding & G 	and Lifecycle Manageme e and Planning nent ethodology and Exploitation opment on & Management	ent (I/II)	
Skills	 Develop an understanding of a national as well as internation. Equip students with an under Management (strategic, operated aspects) Foster a strategic orientating process as well as Technology strategy Clarify activities of Technology strategy Strengthen essential communication and R&D-managerial, organizational Innovation- and R&D-managerial a	onal level rstanding of important experational, organization ion to problem-solving Management and its ir ogy Management (e.g.) unication skills and a land financial issues coment. Further topics to be and tools, relevant to on	elements of al and pro within the apportance for technolog basic under the procession of the discussed and the procession of the discussed and the discussion and the discussed and the discussion and the discussed and the discussion and the	Technology ocess-related innovation for corporate sourcing, rstanding of fechnology-, d include:
Personal Competence				
Social Competence	Interact within a teamRaise awareness for globabl is	ssues		
Autonomy	Gain access to knowledge souInterpret complicated cases	rces		

	Develop presentation skills
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
_	Global Innovation Management: Core qualification: Compulsory Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Compulsory

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

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

Courses				
Title Control Systems Theor		Typ Lecture Recitation	Hrs/wk 2 Section ₂	CP 4
Control Systems Theor	ry and Design (L0657)	(small)	2	2
Module Responsible	Prof. Herbert Werner			
Admission Requirements	INONE			
Recommended Previous Knowledge	Introduction to Control Systems			
Educational Objectives		ents have reached	the following lear	ning results
Professional Competence				
Knowledge	 Students can explain how list space models; they can intexternal excitation as traject. They can explain the system their relationship to state fee. They can explain the significant they can explain observer-beachieve tracking and disturble they can extend all of the absence of the explain the z-train transform. They can explain state spaced time systems. They can explain the experification systems, and how the identity normal equation. They can explain how a system of they can explain how a system of the experification. 	erpret the system ories in state space properties control dback and state eance of a minimal ased state feedback ance rejection ove to multi-input models and trans mental identificati tification problem tate space model	n response to inite e illability and obsestimation, respective realisation ck and how it can multi-output systemationship with fer function mode on of ARX mode can be solved	ervability, and tively and the used to the Laplace and the Laplace are the Lap
Skills	 Students can transform transvice versa They can assess controllate realisations They can design LQG control They can carry out a controutime domain, and decide whi They can identify transfer dynamic systems from expering they can carry out all these Control Toolbox, System Iden 	eility and observa ders for multivarial ller design both in ch is appropriate function models imental data se tasks using sta	bility and constole plants continuous-time for a given sampland state spacendard software	and discrete ing rate e models
Personal Competence				
Social Competence	Students can work in small groups of	on specific problen	ns to arrive at joir	nt solutions.
	Students can obtain information f	rom provided sou	ırces (lecture no	tes, softwa

Autonomy	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	
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Core qualification: Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory Computational Science and Engineering: Specialisation Kernfächer Ingenieurswissenschaften (2 Kurse): Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation III. 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 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: Con	trol Systems Theory and Design
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	WiSe
Content	State space methods (single-input single-output) State space models and transfer functions, state feedback Coordinate basis, similarity transformations Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem Controllability and pole placement State estimation, observability, Kalman decomposition Observer-based state feedback control, reference tracking Transmission zeros Optimal pole placement, symmetric root locus Multi-input multi-output systems Transfer function matrices, state space models of multivariable systems, Gilbert realization Poles and zeros of multivariable systems, minimal realization Closed-loop stability Pole placement for multivariable systems, LQR design, Kalman filter Digital Control Discrete-time systems: difference equations and z-transform Discrete-time state space models, sampled data systems, poles and zeros Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction Least squares estimation, ARX models, persistent excitation Identification of state space models, subspace identification Balanced realization and model order reduction Case study Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools Matlab/Simulink
Literature	 Werner, H., Lecture Notes "Control Systems Theory and Design" T. Kailath "Linear Systems", Prentice Hall, 1980 K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

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

Courses				
Title		Typ	Hrs/wk	СР
The Digital Enterprise	(L0932)	Typ Lecture	2	2
Production Planning a		Lecture	2	2
Production Planning ar	nd Control (L0930)	Recitation	Section 1	1
_		(small) Recitation	Section ₁	
Exercise: The Digital E	nterprise (L0933)	(small)	1	1
Module Responsible				
Admission Requirements	INODE			
Recommended				
	Fundamentals of Production and	Quality Management	t	
Knowledge				
Educational Objectives	LATTER FARING NART CHCCECCHIIIV CTI	idents have reached	the following learn	ing results
Professional				
Competence				
Knowledge	Students can explain the contents of the module in detail and take a critical position to them.			
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence				
<u>-</u>	Students can develop joint soluti	ons in mixed teams a	and present them to	o others.
Autonomy	i			
	Independent Study Time 96, Stud	dy Time in Lecture 84	4	
Credit points	6			
Course	Nene			
achievement	None			
Examination	Written exam			
Examination duration	180 Minuten			
scale	<u> </u>	ingingering. Chasiali	sation II Dradust C	Navalanna.
	International Management and E and Production: Elective Compuls		sation II. Product L	evelopme
	Logistics, Infrastructure and M		on Production an	d Logistic
	Elective Compulsory Biomedical Engineering: Speciali	sation Artificial Orga	ns and Regenerativ	e Medicine
	Elective Compulsory	sation Artificial Orga	ns and negenerativ	re Medicili
	Biomedical Engineering: Specia	alisation Implants a	and Endoprosthes	es: Electiv
	Compulsory	lication Modical Too	chnology and Cont	ral Theor
	Biomedical Engineering: Specia Elective Compulsory	lisation Medical lec	innology and Cont	roi ineor
Assignment for	Biomedical Engineering, Special	isation Management	and Business Adı	ministratio
the Following Curricula	Compulsory			
Carricula	Product Development, Mater Development: Elective Compulso		tion: Specialisatio	on Produ
	Product Development, Materia		n: Specialisation	Productio
	Compulsory		·	
	Product Development, Materials Compulsory	and Production: Sp	ecialisation Materi	als: Electiv
	I COLLIDAISOLY			
	Theoretical Mechanical Engine	ering: Specialisatio	n Product Develo	pment ar

Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

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

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

Module MU92.	1: Electronic Circuits for	Medical Applic	ations	
Courses				
Title Electronic Circuits for I	Medical Applications (L0696)	Typ Lecture	Hrs/wk	CP 3
Electronic Circuits for I	Medical Applications (L1056)	Recitation S (small)	ection 1	2
Electronic Circuits for I	Medical Applications (L1408)	Practical Course	1	1
Кезропзыне				
Admission Requirements	None			
Recommended Previous Knowledge	Fundamentals of electrical enginee	ring		
Educational Objectives	After taking part successfully, stude	ents have reached the	following lear	ning results
Professional Competence				
Knowledge	 Students can explain the base central nervous system Students are able to explain propagation along an axon Students can exemplify the devices Students can describe the synapplications Students can explain the fun Students are able to discuss and artificial eyes 	oin the build-up of a communication between the communication between the communications of prostheses, extractions of prostheses.	n action pote een neurons a noise amplifier e. g. an artificia	ntial and intial and interpretation in the second in the s
Skills	 Students can calculate the potential Students can give scenarios power signal acquisition. Students can develop the bl Students can define the buil eye. 	s for further improver	nent of low-no	oise and lov
Personal Competence				
Social Competence	 Students are trained to solv teams together with experts Students are able to recognifor assistance to the right tine Students can document their results in a way that others of 	with different profess ize their specific limita ne. Ir work in a clear man	ional backgrou ations, so that ner and comm	nd. they can as unicate the
	 Students are able to realisti define actions for improveme Students can break down 	ents when necessary.		

Autonomy	 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	
	CompulsorBonus Form Description	
Course achievement	No None Subject theoretical and practical work	
	No 20 % Excercises	
Examination	Oral exam	
Examination duration and scale		
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	

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

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

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

Module M1150	D: Continuum Mechanics			
Courses				
Title Continuum Mechanics Continuum Mechanics		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 3
Module Responsible	Prof. Christian Cyron	(Critically)		
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 h	nave reached	the following learr	ning results
Professional Competence				
Knowledge	The students can explain the fundame behavior of materials.	ntal concepts	to calculate the	mechanical
Skills	The students can set up balance laws specific aspects, both in applied contexts			on theory to
Personal Competence Social Competence	The students are able to develop solutio form and to develop ideas further.	ns, to present	them to specialis	sts in written
Autonomy	The students are able to assess their independently and on their own ider continuum mechanics and acquire the kr	ntify and sol	ve problems in	•
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 5	6	
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
Assignment for the Following	Computational Science and Engineer Elective Compulsory Materials Science: Specialisation Modelin Mechanical Engineering and Manage Compulsory Mechatronics: Technical Complementary Biomedical Engineering: Specialisation A Elective Compulsory Biomedical Engineering: Specialisation Compulsory	ng: Elective Co ement: Speci Course: Elect artificial Orgar	ompulsory alisation Materia tive Compulsory as and Regenerati	als: Elective ve Medicine:
	Biomedical Engineering: Specialisation	Medical Tech	nnology and Con	trol Theory:

Curricula	Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	Product Development, Materials and Production: Core qualification: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

Module M115	L: Material Modeling			
Courses				
Title Material Modeling (L15 Material Modeling (L15		Typ Lecture Recitation (small)	Hrs/wk 2 Section 2	CP 3
Module	Prof. Christian Cyron	(Siliali)		
Responsible Admission Requirements				
Recommended	Basics of linear and nonlinear continum Mechanics II and Continuum Mechanonlinear strain, free-body principle, energy)	nics (forces and	moments, stress	, linear and
Educational Objectives	After taking part successfully, studen	ts have reached	the following learn	ing results
Professional Competence				
Knowledge	laws			
Skills	The students can implement their of particular, the students can apply the science and evaluate the corresponding	eir knowledge to	various problems	
Personal Competence				
Social Competence	The students are able to develop so develop ideas further.	olutions, to prese	nt them to specio	alists and to
Autonomy	The students are able to assess the independently and on their own ident modeling and acquire the knowledge	tify and solve pro	blems in the area	
Workload in Hours	Independent Study Time 124, Study	Time in Lecture 5	 6	
Credit points	-		<u>-</u>	
Course achievement	None			
Examination	Written exam			
Examination duration and scale				
the Following	Computational Science and Engin Elective Compulsory Materials Science: Specialisation Mod Mechanical Engineering and Man Compulsory Biomedical Engineering: Specialisation Elective Compulsory Biomedical Engineering: Specialisation Compulsory Biomedical Engineering: Specialisation	leling: Elective Co agement: Speci on Artificial Orgar tion Implants a	ompulsory alisation Materia as and Regenerativ nd Endoprosthes	ls: Elective ve Medicine: es: Elective

Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
Product Development, Materials and Production: Core qualification: Elective Compulsory

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

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

Module M1199	9: Advanced Functiona	al Materials		
Courses				
Title Advanced Functional M	Materials (L1625)	Typ Lecture	Hrs/wk 2	CP 6
Module Responsible	Prof. Patrick Huber			
Admission Requirements	None			
Recommended Previous Knowledge		ience, e.g. Materials Scie	nce I/II	
Educational Objectives	After taking part successfully, st	udents have reached the	e following learn	ing results
Professional Competence				
Knowledge	The students will be able to expl their applications in technol semiconductor, modern compos	ogy, in particular met	allic, ceramic,	polymeric,
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.			
Personal Competence				
Social Competence	The students are able to pres further.	ent solutions to specia	lists and to de	velop ideas
	The students are able to			
Autonomy	assess their own strengthgather new necessary exp			
Workload in Hours	Independent Study Time 152, St	tudy 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 qualificated Mechanical Engineering and Compulsory Biomedical Engineering: Special Elective Compulsory Biomedical Engineering: Special Compulsory Biomedical Engineering: Special Elective Compulsory Biomedical Engineering: Special Elective Compulsory Biomedical Engineering: Special Elective Compulsory Theoretical Mechanical Engine Compulsory	Management: Speciali isation Artificial Organs a falisation Implants and alisation Medical Technolisation Management ar	and Regenerative Endoprosthese plogy and Cont and Business Adi	ve Medicine: es: Elective crol Theory: ministration:

Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M127 Biology	9: MED II: Introduction t	to Biochemisti	ry and M	olecula
Біоіоду				
Courses				
Title	mistry and Molecular Biology (L0386)	Typ Lecture	Hrs/wk	CP 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp			
Admission Requirements	None			
Recommended Previous Knowledge	None			
Educational Objectives	After taking part successfully, studen	ts have reached the fo	ollowing learn	ing results
Professional Competence				
Knowledge	 describe basic biomolecules; explain how genetic informatio explain the connection betwee 		Λ;	
Skills	 The students can recognize the importance of disease; describe selected molecular-disease explain the relevance of these 	agnostic procedures;		course of a
Personal Competence				
Social Competence	The students can participate in discu	ssions in research and	d medicine or	n a technica
Autonomy	The students can develop understand literature, by themselves.	ding of topics from th	ne course, usi	ng technica
Workload in Hours	Independent Study Time 62, Study Ti	me in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	60 minutes			
	General Engineering Science (Ge Engineering, Focus Biomechanics: Co General Engineering Science (Ge Engineering: Compulsory General Engineering Science (Ger Biomedical Engineering: Compulsory General Engineering Science (Ger Mechanical Engineering, Focus Biome Electrical Engineering: Specialisation General Engineering Science (Er Engineering, Focus Biomechanics: Co General Engineering Science (Er	mpulsory erman program): S eman program, 7 s eman program, 7 s echanics: Compulsory Medical Technology: I nglish program): Sp mpulsory	pecialisation semester): S semester): S Elective Comp pecialisation	pecialisation pecialisation pulsory Mechanica

Assignment for	Engineering: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
Curricula	Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation
	Biomedical Engineering: Compulsory
	Mechanical Engineering: Specialisation Biomechanics: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration:
	Elective Compulsory
	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: Intro	Course L0386: Introduction to Biochemistry and Molecular Biology		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Hans-Jürgen Kreienkamp		
Language	DE		
Cycle	WiSe		
Content			
	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage		
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008		
Literature			

Module M1333	3: BIO I: Implants and F	racture Healing		
Courses				
Title Implants and Fracture	Healing (L0376)	Typ Lecture	Hrs/wk	CP 3
	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to participate "Implants and Fracture Healing".	e in "Introduction into a	Anatomie" befor	e attending
Educational Objectives	After taking part successfully, stu	dents have reached the	e following learn	ing results
Professional Competence				
Knowledge	The students can describe the diffor their existence. The students can name different given fracture morphologies.	-		•
Skills	The students can determine the static situations under specific as		e human body ι	ınder quasi
Personal Competence				
Social Competence	The students can, in groups, calculation of internal forces.	solve basic numerica	al modeling tas	sks for the
Autonomy	The students can, in groups, calculation of internal forces.	solve basic numerica	al modeling tas	sks for the
Workload in Hours	Independent Study Time 62, Stud	y Time in Lecture 28		
Credit points	3			
Course achievement				
Examination	Written exam			
Examination duration and scale				
Assignment for the Following Curricula	Mechanical Engineering Science	: Compulsory (German program): (German program, 7 omechanics: Compulso (German program, 7 ory (English program): (English program): : Compulsory (English program, 7 omechanics: Compulso	Specialisation semester): Spry semester): Spr Specialisation Specialisation semester): Sprit	pecialisation pecialisation Biomedica Mechanica pecialisation
	Biomedical Engineering: Compuls Mechanical Engineering: Specialis Biomedical Engineering: Specialis	ory sation Biomechanics: Co	ompulsory	

Elect	ve Compulsory				
Biom	edical Engineering: S	Specialisation	Implants and	Endoprostheses:	Elective
Com	ulsory				
Biom	edical Engineering: S	pecialisation N	Medical Technol	ogy and Control	Theory:
Elect	ve Compulsory				
Biom	edical Engineering: Sp	pecialisation M	anagement and	d Business Admin	istration:
Elect	ve Compulsory				
Tech	omathematics: Specia	alisation III. Eng	gineering Sciend	e: Elective Compu	llsory

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

Module M1334	4: BIO II: Biomaterials		
Courses			
Title Biomaterials (L0593)	TypHrs/wkCPLecture23		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous Knowledge	Basic knowledge of orthopedic and surgical techniques is recommended.		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional			
Competence Knowledge	The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use.		
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.		
Personal Competence			
Social Competence	The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers.		
Autonomy	The students are able to acquire information on their own. They can also judge the information with respect to its credibility.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
	Written exam		
Examination duration and scale	90 min		
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory		

Course L0593: Biomaterials	
Тур	Lecture
Hrs/wk	2
	ı

orkidad iii nodi s	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Michael Morlock		
Language			
Cycle			
	Topics to be covered include:		
	Introduction (Importance, nomenclature, relations)		
	2. Biological materials		
	2.1 Basics (components, testing methods)		
	2.2 Bone (composition, development, properties, influencing factors)		
	2.3 Cartilage (composition, development, structure, properties, influencing factors)		
	2.4 Fluids (blood, synovial fluid)		
	3 Biological structures		
	3.1 Menisci of the knee joint		
	3.2 Intervertebral discs		
	3.3 Teeth		
	3.4 Ligaments		
	3.5 Tendons		
Content	3.6 Skin		
	3.7 Nervs		
	3.8 Muscles		
	4. Replacement materials		
	4.1 Basics (history, requirements, norms)		
	4.2 Steel (alloys, properties, reaction of the body)		
	4.3 Titan (alloys, properties, reaction of the body)		
	4.4 Ceramics and glas (properties, reaction of the body)		
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)		
	4.6 Natural replacement materials		
	Knowledge of composition, structure, properties, function and changes/adaptation of biological and technical materials (which are used for replacements in-vivo Acquisition of basics for theses work in the area of biomechanics.		
	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRO Press, 1984.		
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.		
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keel University, September 1978. New York: Wiley, 1998.		
lieralure	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchi Livingstone, 1988.		
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.		

Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berli Springer, 1996.	١,

Courses					
Title Finite Element Method	s (L0291)		Typ Lecture	Hrs/wk	CP 3
Finite Element Method	s (L0804)		Recitation (large)	Section 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	LATTER TAKING DART SUCCE	ssfully, students	have reached	the following learn	ing results
Professional Competence					
Knowledge	The students possess element method and a basis of the method.				
Skills	The students are capa finite elements, assen resulting system of equ	nbling the corre			
Personal Competence					
Social Competence	Students can work in s	mall groups on s	pecific problem	is to arrive at joint	solutions.
	The students are able and develop own finite are critically scrutinized	element routine			
Autonomy					
Workload in Hours	Independent Study Tim	ne 124, Study Tir	me in Lecture 5	6	
Credit points					
Course achievement	CompulsorBonus No 20 %	Form Midterm	D	escription	
Examination	Written exam				
Examination duration and scale					
	Civil Engineering: Core Energy Systems: Core Aircraft Systems Engin Aircraft Systems Engil	qualification: Ele eering: Specialis	ctive Compulso ation Aircraft S	ystems: Elective C	

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

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

Module M1342	2: Polymers			
Courses				
Title		Тур	Hrs/wk	СР
	es of Polymers (L0389) with polymers (L1892)	Lecture Lecture	2 2	3 3
		Lecture		
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / ma	aterial science		
Educational Objectives	After taking part successfully, s	tudents have reached the	following learn	ing results
Professional Competence				
competence	Students can use the knowled analysis.	ge of plastics and define	the necessary	testing and
Knowledge	They can explain the complex i	elationships structure-prop	perty relationsh	nip and
	the interactions of chemical neighboring contexts (e.g. sust	structure of the polym	ers, including	
	Students are capable of			
Skills	- using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.			
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.			
Personal				
Competence	Students can			
		in hotorogonius groups and	document the	· m
6 110 1	- arrive at funded work results			
Social Competence	 provide appropriate feedbac constructively. 	k and nandle feedback (on their own p	репогтапсе
	Students are able to			
	- assess their own strengths an	d weaknesses.		
Autonomy	- assess their own state of le steps on this basis.		ind to define f	urther work
	- assess possible consequences	of their professional activ	ity.	
Workload in Hours	Independent Study Time 124, S	Study Time in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	 Written exam			
Examination				
duration and	180 min			

scale	
Assignment for the Following Curricula	

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

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

Module M0632	2: Regenerative	Medicine			
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine	e (L0347) ering - Regenerative Medio	cine (I 1664)	Seminar Seminar	2 2	3
		enic (E1004)	Seminar	2	3
	Prof. Ralf Pörtner				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part succes	ssfully, students h	ave reached the	e following learn	ing results
Professional Competence					
Knowledge	After successful completion of the module students will be able to describe the basic methods of regenerative medicine and to explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of methods for the cultivation of animal and human cells.				
Skills	 able to use medical databases for acquirierung and presentation of relevant up-to-date data independently able to present their work results in the form of presentations able to carry out basic cell culture methods and the corresponding analysis independently able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 				
Personal Competence	Students are able to wo				given tasks
Social Competence	Students are able to re teachers.	eflect their work o	rally and discus	s it with other s	tudents and
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persons independently including a presentation of the results.				
	Independent Study Tim	ne 124, Study Time	e in Lecture 56		
Credit points					
Course achievement	Compulsor B onus Yes 20 %	Form Written elaborati	on Aus	scription arbeitung zu Rir	
			/ pro	otocol for lecture	e series
Examination	Presentation				

Examination duration and scale	Oral presentation + discussion (30 min)
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory

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

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

Module M0548	8: Bioelectromagnetics:	Principles an	d Applicati	ons
Courses				
_	Principles and Applications (L0371) Principles and Applications (L0373)	Typ Lecture Recitation (small)	Hrs/wk 3 Section 2	CP 5
Module Responsible	Prof. Christian Schuster	(5.116.1)		
Admission Requirements	None			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, stude	ents have reached t	he following lea	rning results
Professional Competence				
Knowledge	Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications. They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology.			
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to another the use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue they can order the effects corresponding to wavelength and frequency respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence Social Competence	Students are able to work togethe are able to present their results			
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.			
Workload in Hours	Independent Study Time 110, Study	y Time in Lecture 70	0	

Credit points	6			
Course achievement	CompulsorBonus Yes 10 %	Form Presentation	Description	
Examination	Oral exam			
Examination duration and scale	45 min			
the Following	Electromagnetic Compa Electrical Engineering: S International Manageme Elective Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Compulsory Biomedical Engineering Elective Compulsory Biomedical Engineering Elective Compulsory Theoretical Mechanical Compulsory	atibility: Elective Conspecialisation Med ent and Engineering: Specialisation Arg: Specialisation Ing: Spe	Microwave Engineering, ompulsory ical Technology: Elective Cong: Specialisation II. Electrical tificial Organs and Regeneral Implants and Endoprosthe Medical Technology and Collanagement and Business Achnical Complementary Councillisation Bio- and Medical Complementary	npulsory I Engineering: tive Medicine: eses: Elective ntrol Theory: dministration: urse: Elective

Course L0371: Bioe	electromagnetics: Principles and Applications
Тур	Lecture
Hrs/wk	3
СР	5
	Independent Study Time 108, Study Time in Lecture 42
	Prof. Christian Schuster
Language	
Cycle	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially FDTD)
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
Content	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
Literature	- 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: Bioe	electromagnetics: Principles and Applications
Тур	Recitation Section (small)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
	Prof. Christian Schuster
Language	
Cycle	
	- Fundamental properties of electromagnetic fields (phenomena)
	- Mathematical description of electromagnetic fields (Maxwell's Equations)
	- Electromagnetic properties of biological tissue
	- Principles of energy absorption in biological tissue, dosimetry
	- Numerical methods for the computation of electromagnetic fields (especially $\ensuremath{FDTD}\xspace)$
	- Measurement techniques for characterization of electromagnetic fields
Content	- Behavior of electromagnetic fields of low frequency in biological tissue
	- Behavior of electromagnetic fields of medium frequency in biological tissue
	- Behavior of electromagnetic fields of high frequency in biological tissue
	- Behavior of electromagnetic fields of very high frequency in biological tissue
	- Diagnostic applications of electromagnetic fields in medical technology
	- Therapeutic applications of electromagnetic fields in medical technology
	- The human body as a generator of electromagnetic fields
	- C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)
Literature	- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)
	- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)
	- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006)

Module M0630	0: Robotics and	Navigation i	n Medicine		
-					
Courses					
Title	on in Modicino (LOZZE)		Typ	Hrs/wk	CP
Robotics and Navigation Robotics and Navigation			Lecture Project Seminar	2 2	3 2
Robotics and Navigation			Recitation Section (small)	on 1	1
Module Responsible	IPINI DIEXANNEI SCHIAE	efer			
Admission Requirements	None				
Recommended Previous Knowledge	 principles of pro 	oth (algebra, analys ogramming, e.g., in b skills			
Educational Objectives	After taking part succe	essfully, students h	ave reached the fol	lowing learn	ing results
Professional					
Competence	÷				
Knowledge	The students can exp illustrate systems and respect to collision d typical systems regard	I their components etection and safe	s in detail. Systems ety and regulation	can be eva	aluated with
Skills	The students are able to design and evaluate navigation systems and robotic systems for medical applications.				
Personal Competence					
Social Competence	The students discuss to incoorporate feedback		r groups, provide h	elpful feedb	ack and can
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tin	ne 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	Compulsor ₽onus Yes 10 % Yes 10 %	Form Written elaborati Presentation	Descri on	otion	
Examination	Written exam				
Examination duration and scale					
	Computer Science: Spe Electrical Engineering: Computational Scienc Robotics: Elective Com International Managen Elective Compulsory Mechatronics: Speciali Biomedical Engineerin Elective Compulsory Biomedical Engineeri	Specialisation Mede and Engineering inpulsory nent and Engineering sation Intelligent Sg: Specialisation A	dical Technology: Elg: Specialisation Syng: Specialisation I g: Specialisation I gstems and Robotic rtificial Organs and	ective Composite Stems Enging I. Electrical Inc. Es: Elective Composite Step Step Step Step Step Step Step St	oulsory neering and Engineering Compulsory ve Medicine:

the Following	Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration:
Carricula	Elective Compulsory
	Product Development, Materials and Production: Specialisation Product
	Development: Elective Compulsory
	Product Development, Materials and Production: Specialisation Production: Elective
	Compulsory Product Development, Materials and Production: Specialisation Materials: Elective
	Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective
	Compulsory
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology:
	Elective Compulsory

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

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

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

Courses					
	cal Technology and Systen cal Technology and Systen		Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Introduction into Medi	cal Technology and Systen	ns (L1876)	Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlaef	er			
Admission Requirements					
Recommended Previous Knowledge	principles of stochastics				
Educational Objectives	TATTOR TAKING NART SHECKS	ssfully, students h	ave reached the follow	ving learn	ing results
Professional Competence					
Knowledge	The students can explain principles of medical technology, including imagin systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.				
Skills	The students are able to evaluate systems and medical devices in the context of clinical applications.				
Personal Competence					
Social Competence	The students describe tasks that are solved in		edical technology as	a project,	and defin
Autonomy	The students can reflect their knowledge and document the results of their work They can present the results in an appropriate manner.				
Workload in Hours	Independent Study Tim	e 110, Study Time	e in Lecture 70		
Credit points	6				
Course achievement	1 V oc 1 0 %	Form Written elaborate Presentation	Descripti ion	on	
Examination	Written exam				
Examination duration and scale	90 minutes				
	General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computer Science: Sp Compulsory Electrical Engineering General Engineering Engineering: Compulso General Engineering Biomedical Engineering Computational Science	ry Science (Germa g: Compulsory pecialisation Com Core qualification Science (Englis ry Science (English g: Compulsory	n program, 7 seme puter and Software : Elective Compulsory sh program): Speci	ester): Sp Engineerinalisation ester): Sp	pecialisationg: Electiv Biomedica pecialisatio
the Following	Elective Compulsory				

Curricula	Computational Science and Engineering: Specialisation Computer Science: Elective
	Compulsory
	Computational Science and Engineering: Specialisation Mathematics & Engineering
	Science: 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
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

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

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

Module M0752	2: Nonlinear Dynamics
Courses	
Title Nonlinear Dynamics (L	Typ Hrs/wk CP 0702) Integrated Lecture 4 6
Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	to develop and research new terms and concepts.
Skills	Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures.
Personal Competence	
Social Competence	Students can reach working results also in groups. Students are able to approach given research tasks individually and to identify and
Autonomy	follow up novel research tasks by themselves.
	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	
Examination duration and scale	
Assignment for the Following Curricula	Riemodical Engineering: Specialisation Implants and Endeprestheses: Flective

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

Courses				
Title Semiconductor Techno Semiconductor Techno		Typ Lecture Practical Course	Hrs/wk 4 2	CP 4 2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous Knowledge	Basics in physics, chemistry, mate	erial science and semicond	luctor device	es
Educational Objectives	After taking part successfully, stu	dents have reached the fo	llowing learn	ing results
Professional Competence				
Knowledge	 to describe and to explain substrates, to discuss in details the releimpact thereof on the fabrication and to present integrated process 	vant fabrication processe of semiconductor device	s, process fl	ows and the
Skills	 Students are capable to analyze the impact of proc to select and to evaluate proc to develop process flows for t 	cesses and	-	
Personal Competence				
Social Competence	Students are able to prepare and well as to present and discuss the			am work a
Autonomy	None			
Workload in Hours	Independent Study Time 96, Stud	y Time in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination				

duration and scale	30 min
Assignment for the Following Curricula	

	Elective Compulsory
Course L0722: Sem	niconductor Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	DE/EN
Cycle	SoSe
Content	 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
	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)
	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
Literature	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M083!	5: Humanoid Roboti	ics		
Courses				
Title Humanoid Robotics (LC	0663)	Typ Seminar	Hrs/wk 2	CP 2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous Knowledge	 Introduction to control 			
Educational Objectives	After taking part successfull	y, students have reached the	following learn	ing results
Professional Competence				
Knowledge	Students can explainStudents learn to approbotics.	humanoid robots. Bly basic control concepts for t	different tasks	in humanoid
Skills	based on specified litStudents generalize of	owledge about selected aspe erature developed results and present prepare and give a presentati	them to the pa	
Personal Competence				
Social Competence	present them	e of developing solutions in i rovide appropriate feedback results		
Autonomy	presentation for specStudents familiarize t	advantages and drawback ific tasks and select the best s themselves with a scientific fic- ions of other students, such	solution eld, are able of	introduce i
Workload in Hours	Independent Study Time 32	, Study Time in Lecture 28		
Credit points				
Course achievement				
Examination Examination duration and scale				
	Compulsory Mechatronics: Specialisation Mechatronics: Specialisation	pecialisation Control and Intelligent Systems and Robe System Design: Elective Con ecialisation Artificial Organs a	otics: Elective (npulsory	Compulsory

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

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

Module M083	8: Linear and Nonline	ar System Identifi	ikation
Courses			
Title Linear and Nonlinear S	System Identification (L0660)	Typ Lecture	Hrs/wk CP 2 3
Module Responsible	Prof. Herbert Werner		
Admission Requirements	INODE		
Recommended Previous Knowledge	 Discrete-time systems 	value decomposition	
Educational Objectives	LATTOR TAKING NART CHICCOCCTIIIIV	tudents have reached the	following learning results
Professional Competence			
Knowledge	 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 Kalmar realisation theory 		
Skills	systemsThey are capable of in based on a neural netwoThey are capable of a	cion of linear and nonlinear rk model pplying subspace algority odels for dynamic systems using standard software	near models for dynamic predictive control scheme thms to the experimental
Personal Competence			
Social Competence	Students can work in mixed gro	oups on specific problems	to arrive at joint solutions.
Autonomy	Students are able to find requ literature, software documenta		
Workload in Hours	Independent Study Time 62, St	udy Time in Lecture 28	
Credit points	3		
Course achievement	LNODE		
Examination	Oral exam		
Examination duration and scale	30 min		
	Electrical Engineering: Speci Compulsory Mechatronics: Specialisation In	alisation Control and telligent Systems and Rob	-

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

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

Courses				
Title Optimal and Robust Co		Typ Lecture Recitation	Hrs/wk 2 Section 2	CP 3
		(small)	2	
поорононо				
Admission Requirements				
Recommended Previous Knowledge	 State space methods 		s)	
Educational Objectives	LATTOR TAKING NART CHACACCTILIN CT	udents have reached	the following learn	ning results
Professional Competence				
Knowledge	 Students can explain the solution of LQ problems. They can explain the du state estimation. They can explain how the stability and performance They can explain how an case of an H2 design problem. They can explain how malends itself to robust control. They can explain how be can guarantee stability and they can explain how an can be represented as line. 	ality between optima ne H2 and H-infinity constraints. LQG design problem blem. nodel uncertainty can roller design ased on the small gair nd performance for an alysis and synthesis	I state feedback norms are used can be formulate be represented in theorem - a robu uncertain plant. conditions on fee	and optime to represe ed as specen a way the ust controll
Skills	 Students are capable multivariable plant model They are capable of reprform of a generalized plait. They are capable of transcontrol loops into constract carrying out a mixed-sens They are capable of conssystem, and of designing They are capable of form matrix inequalities (LMI), and they can carry out all of robust control toolbox). 	s. resenting a H2 or H-i nt, and of using stand lating time and freque raints on closed-loop sitivity design. tructing an LFT uncer a mixed-objective rob nulating analysis and and of using standard	nfinity design pro lard software too ency domain spec sensitivity funct tainty model for ust controller. synthesis condition	oblem in the ls for solving ifications of ions, and an uncertaepons as line olving them
Personal Competence				
	Students can work in small group	•	-	
Autonomy	Students are able to find require literature, software documentation			ecture note

Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	
Assignment for the Following Curricula	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems: Elective Compulsory Energy Systems: Core qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory 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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core qualification: Elective Compulsory

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

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

ourses				
itle larketing of Innovation BL Marketing of Innov		Typ Lecture Project-/problem-	Hrs/wk 4 1	CP 4
		based Learning	1	
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous Knowledge	 Module International Busine Basic understanding of bus decision theory, project ma Bachelor-level Marketing Competitor Strategies, Basi Unerstanding the difference Understanding of the impomarkets Good English proficiency; p 	iness administration princi nagement, international b Knowledge (Marketing In- ics of Buying Behavior) es beweetn B2B and B2C n rtance of managing innove	usiness) struments, narketing	Market ar
Educational Objectives	After taking part successfully, stu	dents have reached the fol	lowing learn	ing results
Professional Competence				
Knowledge	 Specific characteristics in the Approaches for analyzing the development The gathering of information Concepts and approaches product and service develor Approaches and tools for each of new products and innovation Marketing mix elements requirements and challenged Pricing methods for new products and innovation Pricing methods for new products and complete communication concepts and concepts are specified and concepts and concepts are specified and concep	he marketing of innovative he current market situation about future customer not to integrate lead users pment processes ensuring customer-orientative services that take into considerative and services and services a sales forces and personal	n and the fureeds and restand their sion in the dideration to the selling	ture mark quirements needs in evelopmer he specif
Skills	 Design and to evaluate strategies Analyze markets by applyir Conduct forecasts and dev planning Translate customer needs and successfully apply adv service development Use adequate methods to f services Choose suitable pricing innovations Make strategic sales decis sales channels) 	decisions regarding management of the decisions regarding management of the decisions and technology relop compelling scenarios into concepts, prototypes anced methods for custom foster efficient diffusion of strategies and communications.	portfolios as a basis and marke ner-oriented innovative p	for strateg table offer product ar roducts ar ctivities fo

Competence	
	The students will be able to
Social Competence	 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
	The students will be able to
Autonomy	 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	
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
	Global Technology and Innovation Management & Entrepreneurship: Core qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management:
Assignment for the Following Curricula	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	
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	
Cycle	
Content	 V. Customer-oriented Product and Service Engineering Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting VII. Pricing Basics of Pricing, Value-based pricing, Pricing models VIII. Sales Management Basics of Sales Management, Assessing Customer Value, Planning Customer Visits IX. Communications
	 Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 th edition, Boston et al., McGraw Hill
	Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London
	Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press
	Ton implei, E.(2003). Democratizing innovation, Cambridge. Mili 11ess

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

Module M0938	3: Bioprocess Engineering -	Fundamentals	5	
Courses				
Bioprocess Engineering	g - Fundamentals (L0841) g- Fundamentals (L0842)	Typ Lecture Recitation Section (large)	2	CP 3
	g - Fundamental Practical Course (L0843)	Practical Course	2	2
пезропзівіє	Prof. Andreas Liese			
Admission Requirements	None			
Knowledge	none, module "organic chemistry", modu		•	
Educational Objectives	After taking part successfully, students h	nave reached the follo	owing learn	ing results
Professional Competence				
Knowledge	Students are able to describe the basic are able to classify different types of ki well as to differentiate different types of and rheology can be named and mass explained. The students are capal management, sterilization technology ar	netics for enzymes a inhibition. The parar transport processes ble to explain ful	nd microor meters of st in bioreac ndamental	ganisms, as oichiometry tors can be bioprocess
Skills	 After successful completion of this module describe different kinetic approach calculate the corresponding parar predict qualitatively the influen redox equivalents and growth inh analyze bioprocesses on basis metabolic flux equations distinguish between scale-up bioprocesses (anaerobic, aerobic as well as to apply them to current propose solutions to complicated the corresponding models to explore new knowledge resource identify scientific problems with solutions. to document and discuss their paranner 	thes for growth and someters ce of energy gener ibition on the fermen of stoichiometry accriteria for differ as well as microaer at biotechnical proble di biotechnological proces ces and to apply the concrete industrial	ubstrate-up ration, rege tation proce nd to set rent biorea obic) to con m oblems and newly gaine use and t	eneration of ess up / solve actors and mpare them d to deduce ed contents o formulate
Personal Competence Social Competence	After completion of this module partic questions in small teams to enhance opinions and increase their capacity fenvironments.	the ability to take	position to	their own
Autonomy	After completion of this module parti problem in a team independently by org results in a plenum.			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		

Credit points	6
Course	CompulsorBonus Form Description
achievement	Yes None Subject theoretical and practical work
Examination	Written exam
Examination duration and scale	90 min
	General Engineering Science (German program): Specialisation Process Engineering: Compulsory General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering: Compulsory Bioprocess Engineering: Core qualification: Compulsory General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core qualification: Compulsory

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

Course L0842: Bioprocess Engineering- Fundamentals			
Тур	Typ Recitation Section (large)		
Hrs/wk	2		
СР	1		
	Independent Study Time 2, Study Time in Lecture 28		
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng		
Language			
Cycle	SoSe		
	1. Introduction (Prof. Liese, Prof. Zeng)		
	2. Enzymatic kinetics (Prof. Liese)		
	3. Stoichiometry I + II (Prof. Liese)		
	4. Microbial Kinetics I+II (Prof. Zeng)		
Content	5. Rheology (Prof. Liese)		
Content	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: Biop	process Engineering - Fundamental Practical Course
Тур	Practical Course
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

Module M1143	3: Mechanical Design Methodology	
Courses		
Title Mechanical Design Met		
Mechanical Design Met	thodology (L1524) Recitation Section 1 2 (small)	
Module Responsible	TPIOLIOSPI SCOIALIMANN	
Admission Requirements	INODE	
Recommended Previous Knowledge		
Educational Objectives		lts
Professional		
Competence	;	_
Knowledge	Science-based working on product design considering targeted application specific product design techniques	1 0
Skills	Creative handling of processes used for scientific preparation and formulation complex product design problems / Application of various product destechniques following theoretical aspects.	n c sig
Personal Competence		
Social Competence		
Autonomy		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination		
Examination duration and scale	30 min	
Assignment for the Following Curricula	Product Development Materials and Production: Specialization Production	ctive ory tior duc ctive ctive

Compulsory

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

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

Module M1277	7: MED I: Introductio	on to Anat	omy		
Courses					
Title Introduction to Anatom	ny (L0384)		yp ecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Udo Schumacher				
Admission Requirements	None				
Recommended Previous Knowledge	None				
Educational Objectives	After taking part successfully	, students hav	e reached the fo	llowing learn	ing results
Professional Competence					
Knowledge	The students can describe be musculoskeletal system. The students can describe th				
Skills	The students can recognize t development of some com structures and their functions	nmon diseases	s; they can ex	plain the re	
Personal Competence					
-	The students can participat medicine on a professional le		discussions in b	oiomedical re	esearch and
Autonomy	The students are able to participate in conversations themselves.				
Workload in Hours	Independent Study Time 62,	Study Time in	Lecture 28		
Credit points	3				
Course achievement	None				
	Written exam				
Examination duration and scale	90 minutes				
	General Engineering Scien Engineering, Focus Biomecha General Engineering Scien Engineering: Compulsory	anics: Compuls	ory		
the Following	General Engineering Scien Biomedical Engineering: Com General Engineering Scien Mechanical Engineering: Special Engineering Scien Engineering, Focus Biomecha General Engineering Scien Engineering: Compulsory General Engineering Scien Mechanical Engineering, Focus Biomecha Engineering Scien Mechanical Engineering Scien Biomedical Engineering Scien Biomedical Engineering: Com	npulsory ce (German us Biomechanio alisation Medicance (English anics: Compuls nce (English ace (English us Biomechanio	program, 7 secs: Compulsory al Technology: E program): Sp ory program): Sp program, 7 secs: Compulsory	emester): Splective Compecialisation ecialisation emester): Sp	pecialisation pulsory Mechanical Biomedical pecialisation

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			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Lange		
Language			
Cycle			
	General Anatomy	1	
	1 st week:	The Eucaryote Cell	
	2 nd week:		
	2" week:	The Tissues	
	3 rd week:	Cell Cycle, Basics in Development	
	4 th week:	Musculoskeletal System	
		Museuloskeietai system	
	5 th week:	Cardiovascular System	
	6 th week:	Respiratory System	
	7 th week:	Genito-urinary System	
Content	8 th week:	Immune system	
	9 th week:	Digestive System I	
	10 th week:	Digestive System II	
	11 th week:	Endocrine System	
	12 th week:	Nervous System	
	13 th week:	Exam	
Literature	Adolf Faller/Michae Stuttgart, 2012	l Schünke, Der Körper des Menschen, 16. Auflage, Thieme Verlag	

Module M1280	0: MED II: Introduction to Physiology
Courses	
Title Introduction to Physiol	Typ Hrs/wk CP logy (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	
Knowledge	 The students can describe the basics of the energy metabolism; describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.
Skills	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	
Social Competence	The students can conduct discussions in research and medicine on a technical level. The students can find solutions to problems in the field of physiology, both analytical and metrological.
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	INONE
Examination	Written exam
Examination duration and scale	60 minutes
scale	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation
	Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical
Assianment for	Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory
the Following	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory
	General Engineering Science (English program, 7 semester): Specialisation

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

Course L0385: Introduction to Physiology			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Gerhard Engler		
Language	DE		
Cycle	SoSe		
Content			
Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67 Thieme Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier			

Module M127 Therapy	8: MED I: Introduction to Radiology and Radiation		
Courses			
Title Introduction to Radiolo	Typ Hrs/wk CP gy and Radiation Therapy (L0383) Lecture 2 3		
	Prof. Ulrich Carl		
Admission Requirements	None		
Recommended Previous Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy. The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine). The students can describe the patients' passage from their initial admittance through to follow-up care. Diagnostics The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US). The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques. The students can choose the right treatment method depending on the patient's clinical history and needs. The student can explain the influence of technical errors on the imaging techniques. The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.		
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion. The students can develop adequate therapy concepts and relate it to the radiation biological aspects. The students can use the therapeutic principle (effects vs adverse effects)		
Skills	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning). The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).		
	Diagnostics		

	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.		
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.		
Personal Competence			
	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.		
	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.		
Autonomy	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	INONA		
Examination	Written exam		
Examination duration and scale	90 minutes		
the Following	General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration:		

Course L0383: Introduction to Radiology and Radiation Therapy		
Тур	Lecture	
Hrs/wk	2	
СР	3	
	3	

	Independent Study Time 62, Study Time in Lecture 28 Prof. Ulrich Carl, Prof. Thomas Vestring		
Language	DE -		
Cycle			
Content	The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word "X-ray" at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend or special big units, which determine a predefined sequence in their respective departments		
	Technik der medizinischen Radiologie" von T. + J Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999		
	"Klinische Strahlenbiologie" von Th. Herrmann, M. Baumani und W. Dörr – Austlage Werleg Urban & Fischer erschienen 02 03 2006		
	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		
Literature	 "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 - erschiener 18.07.2012		
	ISBN: 978-3-13-329716-5		
	 "Praxismanual Strahlentherapie" von Stöver / Feyer - 		
	1. Auflage - Springer-Verlag GmbH - erschienen 02.06.2000		

Module M1332	2: BIO I: Experimental Mo	ethods in Biom	echanics	
Courses				
Title Experimental Methods	in Biomechanics (L0377)	Typ Lecture	Hrs/wk 2	CP 3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
	It is recommended to participat attending "Experimentelle Methode		nd Frakturheilu	ng" before
Educational Objectives	After taking part successfully, stude	ents have reached the	following learn	ing results
Professional Competence				
Knowledge	The students can describe the diffe for their existence. The students can name different to given fracture morphologies.	•		•
	The students can describe differmovements, and choose the adequate		•	forces and
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.			
Personal Competence				
Social Competence		·		
Autonomy	The students can, in groups, solve b	·	sks.	
:	Independent Study Time 62, Study	Time in Lecture 28		
Credit points				
Course achievement				
-	Written exam			
Examination duration and scale	90 min			
	General Engineering Science (C Engineering, Focus Biomechanics: C General Engineering Science (C Engineering: Compulsory General Engineering Science (G Mechanical Engineering, Focus Biom General Engineering Science (G	Compulsory German program): erman program, 7 nechanics: Compulsor	Specialisation semester): Sp	Biomedical
the Following	Biomedical Engineering: Compulsor General Engineering Science (Engineering: Compulsory General Engineering Science (Engineering, Focus Biomechanics: C General Engineering Science (E Mechanical Engineering, Focus Biom General Engineering Science (E Biomedical Engineering: Compulsor Mechanical Engineering: Specialisat	y English program): English program): Compulsory nglish program, 7 nechanics: Compulsor nglish program, 7 y	Specialisation Specialisation semester): Spring Spr	Biomedical Mechanical Decialisation

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

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

Module M1335	5: BIO II: Artificial Joint	Replacement		
Courses				
Title Artificial Joint Replacer	ment (L1306)	Typ Lecture	Hrs/wk 2	CP 3
	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	Basic knowledge of orthopedic ar	nd surgical techniques is	recommended	
Educational Objectives	After taking part successfully, stu	dents have reached the	following learn	ing results
Professional Competence				
Knowledge	The students can name the differ			
Skills	The students can explain the adendoprotheses.	Ivantages and disadvan	tages of differ	ent kinds of
Personal Competence				
Social Competence	The students are able to discuss and the teachers.	issues related to endopr	othese with stu	ıdent mates
Autonomy	The students are able to acquire information with respect to its cre		n. They can als	so judge the
Workload in Hours	Independent Study Time 62, Stud	ly Time in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and scale	90 min			
Assignment for the Following Curricula	Elective Compulsory	pulsory Nano and Hybrid Materia sation Artificial Organs a sation Implants and Endo isation Medical Techno sation Management and ring: Technical Comple	als: Elective Co and Regenerative oprostheses: Co logy and Cont d Business Ada mentary Cours	mpulsory ve Medicine: ompulsory crol Theory: ministration: se: Elective

Course L1306: Arti	ficial Joint Replacement
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	
Cycle	SoSe
	Inhalt (deutsch)
	 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)
Content	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)
	Literatur:
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.
Literature	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994
Enceracare	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	5: Feedback Control in Medical Technology		
Courses			
Title Feedback Control in Mo	Typ Hrs/wk CP edical 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			
	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.		
Knowledge	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system fo example in for anesthesia control.		
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will be illustrated. The operation of simple equivalent circuits will be discussed.		
Skills	Application of modeling, identification, control technology in the field of medical technology.		
Personal Competence			
Social Competence	Students can develop solutions to specific problems in small groups and present their results (e.g. during project week)		
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points			
Course achievement	None		
Examination	Oral exam		
Examination duration and scale	20 min		
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine:		

Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory

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

Courses				
Title	ontrol (10661)	Typ Lecture	Hrs/wk 2	CP 3
Advanced Topics in Co		Recitation	Section 2	3
Advanced Topics in Co	ilitioi (L0002)	(small)		3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	H-infinity optimal control, mixed-s	ensitivity design, line	ear matrix inequal	lities
Educational Objectives	After taking part successfully, stud	dents have reached t	he following learn	ning results
Professional Competence				
Knowledge	 Students can explain the a scheduling approach They can explain the representations the properties. They can explain how stab can be formulated as LMI construction to the properties. They can explain how grides and synthesis problems for LPV They are familiar with polytics some of the basic synthesis structures. Students can explain how grown communication topology of they can explain the comprotocols. They can explain analysis a involving either LTI or LPV and the distributed systems that are they can explain (in outling such distributed systems distributed controllers. 	sentation of nonlinear sility and performance on ditions ding techniques can be systems topic and LFT represes techniques associal graph theoretic concernitions are propertied as a synthesis condition agent models state space represed discretized according the extension of	r systems in the free conditions for I be used to solve a entations of LPV sted with each of spots are used to response for formation of spatial and to an actuator, the bounded response for the bounded response for the spatial spa	orm of quasi LPV system analysis and systems and these mode epresent the r consensu control loop
Skills	 Students are capable of carry out a mixed-sensitivi do this using polytopic, LFT They are able to use stand for these tasks Students are able to design agents with either LTI or LP 	ty design of gain-sc or general LPV mode ard software tools (N gn distributed forma	heduled controlle els Matlab robust con tion controllers fo	trol toolbox

	Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox
Personal Competence Social Competence Autonomy	Students can work in small groups and arrive at joint results. Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory Computational Science and Engineering: Specialisation Systems Engineering and Robotics: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory 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: Core qualification: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory

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

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

Thesis

Module M-002	: Master Thesis
Courses	
Title	Typ Hrs/wk CP
Module Responsible	Professoren der TUHH
Admission Requirements	
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing 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	 The students are able: To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/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	
Social Competence	 Students can Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.
	Students are able:
Autonomy	 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
	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy and Environmental Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Materials Science: Thesis: Compulsory Mathematical Modelling in Engineering: Theory, Numerics, Applications: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mecharionics: 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 Process Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory