

Module Manual

Master of Science (M.Sc.)

Biomedical Engineering

Cohort: Winter Term 2019

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Program description

Content

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

Career prospects

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

Learning target

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

Graduates are able to:

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

Core Qualification

Module M0523: Busin	ess & Management
Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	 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: Non-technical Courses for Master Dagmar Richter **Module Responsible Admission Requirements** None **Recommended Previous** Knowledge

Professional Competence

Knowledge The Nontechnical Academic Programms (NTA)

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

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

The Learning Architecture

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

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

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

Teaching and Learning Arrangements

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

Fields of Teaching

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

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

The Competence Level

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

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

Specialized Competence (Knowledge)

Students can

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

Skills Professional Competence (Skills)

In selected sub-areas students can

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

Davisanal Commetence	
Personal Competence	Personal Competences (Social Skills)
Social competence	Tersonal competences (Social Skins)
	 to learn to collaborate in different manner, to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	Personal Competences (Self-reliance) Students are able in selected areas
	to reflect on their own profession and professionalism in the context of real-life fields of application
	 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: Appli	ed Statistics						
Courses							
Title					Тур	Hrs/wk	СР
Applied Statistics (L1584)					Lecture	2	3
Applied Statistics (L1586)					Project-/problem-based Learning Recitation Section (small)	2	2 1
Applied Statistics (L1585) Module Responsible	Prof Michael Morlo	nck			Recitation Section (Smail)	1	1
Admission Requirements	None	ick .					
		f statistical me	thods				
Knowledge	busic knowledge o	i statisticai iiic	ti lous				
Educational Objectives	After taking part si	uccessfully, stu	dents have reac	hed the followin	g learning results		
Professional Competence	3 1 3 1	,,,,,			<u> </u>		
•	Students can expla	Students can explain the statistical methods and the conditions of their use.					
Skills	Students are able	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results					
Personal Competence			, 3			·	
Social Competence	Team Work, joined presentation of results						
Autonomy	To understand and interpret the question and solve						
Workload in Hours	Independent Study	Independent Study Time 110, Study Time in Lecture 70					
Credit points	6						
Course achievement	Compulsory Bonus	Form		Description			
	Yes None	Written el	aboration				
Examination	Written exam						
Examination duration and	90 minutes, 28 que	estions					
scale							
Assignment for the	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory						
Following Curricula	Mechatronics: Specialisation System Design: Elective Compulsory						
	Mechatronics: Spe	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory					
	Biomedical Engine			-			
				-	n: Elective Compulsory		
		-	-		ourse: Elective Compulsory		
	Theoretical Mecha	nical Engineeri	ng: Specialisation	n Bio- and Medio	cal Technology: Elective Compu	ılsory	

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

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

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

Courses				
Title		Tree	Hrs/wk	СР
Medical Imaging Systems (L0819)		Typ Lecture	4	6
Module Responsible	Dr. Michael Grass	Eccurc		
Admission Requirements	None			
Recommended Previous				
Knowledge	Tione			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence	Arter taking part successivily, stauchts have reached the	Tollowing learning results		
Knowledge				
Kilowieage	Students can:			
	Stadents can.			
	 Describe the system configuration and component 	s of the main clinical imaging	g systems;	
	Explain how the system components and the over-			
	Explain and apply the physical processes that make		vith the fundamental phy	sical equations;
	Name and describe the physical effects required to			
	Explain how spatial and temporal resolution can be		acterize the images gene	erated;
	Explain which image reconstruction methods are u	sed to generate images;		
	Describe and explain the main clinical uses of the differe	nt systems.		
Skills	Students are able to:			
	Explain the physical processes of images and assignments	in to the systems the basic n	nathematical or physical	equations require
	Calculate the parameters of imaging systen	•		
	 Determine the influence of different system 			f imaging system
	 Explain the importance of different imaging 			3 3 7
	Select a suitable imaging system for an application.			
Personal Competence				
Social Competence	none			
Autonomy	Students can:			
	Understand which physical effects are used in any	lical imaging		
	 Understand which physical effects are used in med Decide independently for which clinical issue a med 			
	Beelde independently for which chinical issue a file	asaring system can be asea.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Medical Technology	: Elective Compulsory		
Following Curricula	Biomedical Engineering: Core Qualification: Compulsory			
	Product Development, Materials and Production: Specialis	sation Product Development:	Elective Compulsory	
	Product Development, Materials and Production: Specialis	sation Production: Elective Co	ompulsory	
	Product Development, Materials and Production: Specialis	sation Materials: Elective Cor	npulsory	
	Theoretical Mechanical Engineering: Technical Compleme	entary Course: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Specialisation Bio- a	nd Medical Technology: Elect	ive Compulsory	

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

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

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

Course L1600: Medical Basic	s and Pathology II
Тур	Lecture
Hrs/wk	2
СР	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Johannes Kluwe
Language	DE
Cycle	WiSe
Content	Major diseases of
	 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 Basic	s 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				
Fitle	ant. Materials and Braduction (L1566)	Тур	Hrs/wk	СР
	pent, Materials and Production (L1566)	Practical Course	6	6
Module Responsible				
Admission Requirements Recommended Previous				
Knowledge	Lectures: Mechanics I-III Lectures: Integrated Product Development Materials: Lectures: Structural Metallic Materials, Me Lectures: Structure and Properties of Pol Composites Production: Lecture: Production Engineering Lectures: Forming and Cutting Technology Lectures: Machine Tools and Robotic	tallic Materials for Aircraft Applications, Ir ymers, Structure and Properties of Com		
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
	represent more complex context of differe describe functionality of modern measurer		nologies.	
Skills	Students are capable of applying theoretical knowledge for practic applying provided experimental methods analyzing and evaluating experimental res applying modern measurement instrumen	for examining contexts of different fields sults by using provided methods.	of study.	
Personal Competence Social Competence	Students can carry out and document experimental wor present and discuss experimental results in		<i>i</i> .	
Autonomy	Students are able to carry out parts of experimental work indep choose and apply suitable instruments. assess own strengths and weaknesses.	pendently guided by teachers.		
Workload in Hours	Independent Study Time 96, Study Time in Lectu	re 84		
Credit points	6			
Course achievement	None			
Examination	Written elaboration			
Examination duration and scale				
_	Biomedical Engineering: Core Qualification: Com			
Following Curricula	Product Development, Materials and Production:	Core Qualification: Compulsory		

Course L1566: Practical Cour	rse Product Development, Materials and Production		
Тур	Practical Course		
Hrs/wk	6		
СР	6		
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84		
Lecturer	Prof. Wolfgang Hintze, Prof. 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	Product Development:		
	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		
	Evaluation of stock removal processes		
	Analysis of basic laws in production logistics		
	Analysis of positioning behaviour and trajectory accuracy of industrial robots		
Literature	Nach Themenstellung / depending on topic		

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

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

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

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

Specialization Implants and Endoprostheses

Module M0623: Intell	igent Systems	in Medicine				
Courses						
Title			T	ур	Hrs/wk	СР
Intelligent Systems in Medicine (L0	331)			ecture	2	3
Intelligent Systems in Medicine (L0	334)		Pr	roject Seminar	2	2
Intelligent Systems in Medicine (L0	333)		Re	ecitation Section (small)	1	1
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous	principles of m	ath (algebra, analysis/cal	culus)			
Knowledge	principles of st		caras,			
		rogramming, Java/C++ ar	nd R/Matlab			
	advanced prog	ramming skills				
Educational Objectives	Arter taking part succ	cessfully, students have re	eached the following	learning results		
Professional Competence	The students are abl	- *	:-:! ++			
Knowledge		e to analyze and solve cl nning. They are able to e:				
		he students can compare				
		ical data and explain cha				
	and safety requireme		andinges due to the e	car natare or the auto	a arra ito degarsitio	. and dde to privae,
Skills	_	e reasons for selecting a			ession, and predicti	on. 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 group	os, provide helpful fe	edback and can incoorpo	rate feedback into	their work.
Autonomy	The students can ref	last their knowledge and	document the result	ts of their work. They so	n procent the resu	lts in an appropriate
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
	manner.					
Workload in Hours	Independent Study T	ime 110, Study Time in Le	ecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 % Yes 10 %	Written elaboration Presentation				
Examination	Written exam	Fresentation				
Examination duration and	90 minutes					
scale	50 Hilliates					
Assignment for the	Computer Science: Science	necialisation Intelligence	Engineering: Flective	Compulsory		
•	Computer Science: Specialisation Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory					
		ce and Engineering: Speci			Elective Compulsor	У
		lisation Intelligent System			,	-
	Biomedical Engineeri	ng: Specialisation Artificia	al Organs and Regene	erative Medicine: Elective	e Compulsory	
	Biomedical Engineeri	ng: Specialisation Implant	ts and Endoprosthese	es: Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation Medica	l Technology and Cor	ntrol Theory: Elective Co	mpulsory	
	Biomedical Engineeri	ng: Specialisation Manage	ement and Business	Administration: Elective (Compulsory	
	Theoretical Mechanic	al Engineering: Technical	Complementary Cou	ırse: Elective Compulsory	/	
	Theoretical Mechanic	al Engineering: Specialisa	ation Bio- and Medica	l Technology: Elective Co	ompulsory	

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

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

Courses				
Title		Тур	Hrs/wk	CP
Intelligent Autonomous Agents and Intelligent Autonomous Agents and		Lecture Recitation Section (small)	2	4 2
	-	Recitation Section (Smail)	2	2
Module Responsible				
Admission Requirements	None			
	Vectors, matrices, Calculus			
Knowledge	After taking part suggestfully, students have	reached the following learning regults		
Educational Objectives	After taking part successfully, students have r	reached the following learning results		
Professional Competence	Charles and compared the control of	d-fl i-t-lli i- tfti b-bi		
Knowieage	Students can explain the agent abstraction, of	cribe the main features of environments. The		
		ems and algorithms for solving these problem		
		w Bayesian networks can be employed as a kr		
		addition, students can define decision makin		
	·	the state of the environment. In this context,		
		n problems, and they can recall techniques for		
		neous localization and mapping, and can exp		
		ition problems and decision making in a multi-		
	of equilibria, social choice functions, voting pr			
Skills	s Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application			
	students can derive decision trees and apply	basic optimization techniques. For those app	lications they can	also create Bayes
		apply bayesian reasoning for simple queries		
		agent scenarios. For simple and complex deci		
		n multi-agent situations students will apply te		
		ecision making students will apply different vo	ting protocols and	compare and expl
	the results.			
Personal Competence				
•	Students are able to discuss their solutions to	problems with others. They communicate in F	nalish	
Social Competence	Students are able to discuss their solutions to	problems with others. They communicate in L	rigiisii	
Autonomy	Students are able of checking their understan	ding of complex concepts by solving varaints	of concrete probler	ms
Workload in Hours	Independent Study Time 124, Study Time in L	ecture 56		
Credit points	,			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Computer Science: Specialisation Intelligence	Engineering: Elective Compulsory		
Following Curricula		Specialisation II. Information Technology: Electi	ve Compulsory	
3	Mechatronics: Technical Complementary Cour	,	, ,	
	· · ·	al Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implar	•	, , ,	
		al Technology and Control Theory: Elective Cor	npulsory	
		gement and Business Administration: Elective (
	Theoretical Mechanical Engineering: Technica			

Tyn	Lecture	
	2	
-,	4	
_	Independent Study Time 92, Study Time in Lecture 28	
	Rainer Marrone	
	EN EN	
Cycle		
Content	WIGE	
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, productive, 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-cast 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, Markot 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-pr	
	mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwai Theorem	
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 1 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, Cambridg University Press, 2009 	

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

Module M1230: Selec	ted Topics of Biomedical Engineering	g - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	663)	Seminar	2	3
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
-	Biomedical Engineering: Specialisation Management	•		
	Biomedical Engineering: Specialisation Artificial Organ			
	Diometaca Engineering. Specialisation Artificial Organ	is and regenerative medicine. Elective	Compaisory	

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

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

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

Course L1588: Development	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	90 Minuten		
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	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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 Me	thods in Biomechanics
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	 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 Biom	ourse L1890: Seminar Biomedical Engineering		
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Referat		
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

Course L1130: Six Sigma			
Тур	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	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		

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

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

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

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

Module M0746: Micro	system Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Microsystem Engineering (L0680)		Lecture	2	4
Microsystem Engineering (L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper			
Admission Requirements	None			
Recommended Previous	Basic courses in physics, mathematics and electric engineering			
Knowledge				
-	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge	The students know about the most important technologies ar actuators.	nd materials of MEMS as well as	their application	ons in sensors and
Skills	Students are able to analyze and describe the functional be microsystems.	ehaviour of MEMS components	and to evaluat	e the potential of
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group	and to present the results accord	lingly.	
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with			
	other fields.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description No 10 % Presentation			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the	Electrical Engineering: Core Qualification: Compulsory			
Following Curricula	Computational Science and Engineering: Specialisation Systems	Engineering and Robotics: Electi	ve Compulsory	
	International Management and Engineering: Specialisation II. Ele			
	International Management and Engineering: Specialisation II. Mo			
	International Management and Engineering: Specialisation II. El	ectrical Engineering: Elective Com	npulsory	
	International Management and Engineering: Specialisation II. Mo	echatronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Mecha	tronics: Elective Compulsory		
	Mechanical Engineering and Management: Specialisation Mecha	atronics: Elective Compulsory		
	Mechatronics: Specialisation System Design: Elective Compulso	ry		
	Mechatronics: Specialisation System Design: Elective Compulso	ry		
	Biomedical Engineering: Specialisation Artificial Organs and Reg	generative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosth	' '		
	Biomedical Engineering: Specialisation Medical Technology and	•	-	
	Biomedical Engineering: Specialisation Management and Busine	•	ulsory	
	Microelectronics and Microsystems: Core Qualification: Elective			
	Theoretical Mechanical Engineering: Technical Complementary			
	Theoretical Mechanical Engineering: Specialisation Bio- and Mec			
	Theoretical Mechanical Engineering: Specialisation Bio- and Med	alcai Technology: Elective Compul	іѕогу	

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

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	2 Engineering Meenunes			
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge	Students are able to denote terms and concepts of Vib	ration Theory and develop them furt	her.	
Skills	Students are able to denote methods of Vibration Theory and develop them further.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vibration Theory.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulso	ry		
Following Curricula	International Management and Engineering: Specialisa	tion II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	on Mechatronics: Elective Compulsor	У	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs	•	e Compulsory	
	Biomedical Engineering: Specialisation Implants and En		terri	
	Biomedical Engineering: Specialisation Medical Techno	•		
	Biomedical Engineering: Specialisation Management as		Compulsory	
	Product Development, Materials and Production: Core (• •		
	Naval Architecture and Ocean Engineering: Core Qualif Theoretical Mechanical Engineering: Core Qualification			
	Theoretical Mechanical Engineering: Core Qualification Theoretical Mechanical Engineering: Technical Comple		V	
	medietical Mechanical Engineering. Technical Comple	mentary course. Elective Compulsor	у	

Course L0701: Vibration The	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.			

C				
Courses				
Title		Typ	Hrs/wk	CP 4
Microsystems Technology (L0724) Microsystems Technology (L0725)		Lecture Project-/problem-ba	2 ased Learning 2	2
Module Responsible	Prof. Hoc Khiem Trieu	.,,		
Admission Requirements				
Recommended Previous		semiconductor technology		
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results	1	
Professional Competence				
Knowledge	Students are able			
	he was such and he soulein source to be			
	to present and to explain current fabr microsensors and microactuators, as well as	·		as for the fabrication
	to explain in details operation principles	of microsensors and microactuators a	nd	
	to discuss the potential and limitation of	microsystems in application.		
Skills	Students are capable			
	to analyze the feasibility of microsystem.	5,		
	to develop process flows for the fabrication	on of microstructures and		
	to apply them.			
Barranal Campatanas				
Personal Competence Social Competence				
30ciai competence				
	Students are able to prepare and perform the	eir lab experiments in team work as w	vell as to present and di	scuss the results in fro
	of audience.			
Autonomy	None			
Workload in Hours	Independent Study Time 124, Study Time in	ecture 56		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes None Subject theoretical	andStudierenden führen in Kleingr		
	practical work	präsentiert und diskutiert die T	heorie sowie die Ergebr	niise ihrer Labortätigke
		vor dem gesamten Kurs.		
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoele	ctronics and Microsystems Technolog	y: Elective Compulsory	
Following Curricula			orbania en ar	T
	Computational Science and Engineering: Spe			iisory
	International Management and Engineering: Biomedical Engineering: Specialisation Artific	•		
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla			
	Biomedical Engineering: Specialisation Medic	•		
	Biomedical Engineering: Specialisation Management			
	Microelectronics and Microsystems: Core Qua			

Course L0724: Microsystems	Technology
-	
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; 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, SUB, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer) Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensors, Lambda probe, MOSF
	 DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002 N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010 G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

	e Elements Methods
Courses	
Title	Typ Hrs/wk CP
Finite Element Methods (L0291)	Lecture 2 3
Finite Element Methods (L0804)	Recitation Section (large) 2 3
Module Responsible	
Admission Requirements	
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give overview of the theoretical and methodical basis of the method.
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the correspo system matrices, and solving the resulting system of equations.
Personal Competence Social Competence	e Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element rou Problems can be identified and the results are critically scrutinized.
Workload in Hours	s Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	No 20 % Midterm
Course achievement	No 20 / Placem
Course achievement Examination	
	Written exam
Examination	Written exam 1 120 min
Examination Examination duration and scale	Written exam 1 120 min
Examination Examination duration and scale Assignment for the	Written exam 1 120 min
Examination Examination duration and scale Assignment for the	Written exam 1 20 min 2 Civil Engineering: Core Qualification: Compulsory 3 Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory
Examination Examination duration and scale Assignment for the	Written exam 1 20 min 2 Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory
Examination Examination duration and scale Assignment for the	Written exam 120 min 2 Civil Engineering: Core Qualification: Compulsory 2 Energy Systems: Core Qualification: Elective Compulsory 3 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 4 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 5 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 6 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory
Examination Examination duration and scale Assignment for the	Mvritten exam 120 min 1 Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory
Examination Examination duration and scale Assignment for the	Mritten exam 1 120 min 1 120 min 2 Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory
Examination Examination duration and scale Assignment for the	Written exam 1 120 min 2 Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory
Examination Examination duration and scale Assignment for the	Mritten exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Written exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Written exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Written exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Written exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Written exam 120 min 2 Civil Engineering: Core Qualification: Compulsory 2 Energy Systems: Core Qualification: Elective Compulsory 3 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 4 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 5 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 7 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 8 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 9 International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory 9 International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 9 International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 9 Mechatronics: Core Qualification: Compulsory 9 Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory 9 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory 9 Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
Examination Examination duration and scale Assignment for the	Written exam 120 min 120 min 120 min 13
Examination Examination duration and scale Assignment for the	Myritten exam d 120 min a Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: 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
Examination Examination duration and scale Assignment for the	Myritten exam 120 min 2 Civil Engineering: Core Qualification: Compulsory 2 Energy Systems: Core Qualification: Elective Compulsory 3 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 4 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 5 Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory 6 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 7 Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory 8 International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory 9 International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 9 International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory 9 Mechatronics: Core Qualification: Compulsory 9 Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory 9 Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory 10 Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory 11 Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory 12 Product Development, Materials and Production: Core Qualification: Compulsory

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

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

Module M0814: Techr	nology Management		
Courses			
Title	Тур	Hrs/wk	СР
Technology Management (L0849)	Project-/problem-based Learning	3	3
Technology Management Seminar	(L0850) Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt		
Admission Requirements	None		
	Bachelor knowledge in business management		
Knowledge			
	After taking part successfully, students have reached the following learning results		
Professional Competence	Students will gain doon incights into		
Knowieuge	Students will gain deep insights into:		
	International R&D-Management		
	Technology Timing Strategies		
	Technology Strategies and Lifecycle Management (I/II)		
	Technology Intelligence and Planning		
	Technology Portfolio Management Technology Portfolio Mahagement		
	Technology Portfolio Methodology Technology Assuicition and Exploitation		
	Technology Acquisition and Exploitation IR Management		
	IP Management Organizing Technology Development		
	Technology Organization & Management		
	Technology Funding & Controlling		
G! !!!			
SKIIIS	The course aims to:		
	Develop an understanding of the importance of Technology Management - on a national a	s well as inter	national level
	Equip students with an understanding of important elements of Technology Man	agement (st	rategic, operationa
	organizational and process-related aspects)		
Foster a strategic orientation to problem-solving within the innovation process as well as Technology Man importance for corporate strategy		s Technology	Management and it
	Clarify activities of Technology Management (e.g. technology sourcing, maintenance and each of the source of		and financial iccus
	 Strengthen essential communication skills and a basic understanding of managerial, c concerning Technology-, Innovation- and R&D-management. Further topics to be discussed 		and imancial issue
	Basic concepts, models and tools, relevant to the management of technology, R&D and in	novation	
	Innovation as a process (steps, activities and results)		
Personal Competence			
Social Competence	Interact within a team		
	Raise awareness for globabl issues		
	* Italse awareness for globalitissues		
Autonomy	Gain access to knowledge sources		
	Discuss recent research debates in the context of Technology and Innovation Managemen	t	
	Develop presentation skills		
	Discussion of international cases in R&D-Management		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70		
Credit points			
Course achievement			
Examination	Written exam		
Examination duration and	90 minutes		
scale			
Assignment for the			
Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compuls	ory	
	International Management and Engineering: Specialisation I. Electives Management: Elective Cor	npulsory	
	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Com	npulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Management and Business Administration: Compulsory		

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

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

Module M0846: Contr	ol Systems Theory and Design			
Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Design		Lecture	2	4
Control Systems Theory and Design		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
Kecommended Previous Knowledge	Introduction to Control Systems			
	After taking part successfully, students have reached	the following learning results		
Professional Competence	, , , , , , , , , , , , , , , , , , , ,			
Knowledge	Students can explain how linear dynamic sy:			
	response to initial states or external excitation They can explain the system properties contrestimation, respectively They can explain the significance of a minima They can explain observer-based state feedba They can extend all of the above to multi-inpu They can explain the z-transform and its relat They can explain state space models and tran They can explain the experimental identification be solved by solving a normal equation They can explain how a state space model can	n as trajectories in state space ollability and observability, and their redreads and how it can be used to achieve trait multi-output systems onship with the Laplace Transform sfer function models of discrete-time system of ARX models of dynamic systems, a	ationship to state cking and disturb tems nd how the ident	e feedback and state pance rejection
Skills	 Students can transform transfer function models into state space models and vice versa They can assess controllability and observability and construct minimal realisations They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropria for a given sampling rate They can identify transfer function models and state space models of dynamic systems from experimental data They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) 		ital data	
·	Students can work in small groups on specific proble Students can obtain information from provided sou		ation, experimer	nt guides) and use it
	when solving given problems. They can assess their knowledge in weekly on-line to	ests and thereby control their learning pr	ogress.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture	56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
scale				
•	Computer Science: Specialisation Intelligence Engine	, ,		
Following Curricula	Electrical Engineering: Core Qualification: Compulsor Energy Systems: Core Qualification: Elective Compul			
	Aircraft Systems Engineering: Specialisation Aircraft			
	Aircraft Systems Engineering: Specialisation Avionic		ilsory	
	Computational Science and Engineering: Specialisati	on II. Engineering Science: Elective Com	oulsory	
	International Management and Engineering: Speciali			
	International Management and Engineering: Specialis		ory	
	Mechanical Engineering and Management: Specialisa Mechatronics: Core Qualification: Compulsory	ation Mechatronics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Orga	ins and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants and	•	,,	
	Biomedical Engineering: Specialisation Medical Tech	nology and Control Theory: Compulsory		
	Biomedical Engineering: Specialisation Management		ompulsory	
	Product Development, Materials and Production: Cor Theoretical Mechanical Engineering: Core Qualification			

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

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

Module M0867: Produ	ction Planning & Control an	d Digital Enterprise		
Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (Li	0929)	Lecture	2	2
Production Planning and Control (Li	0930)	Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0933) Recitation Section (small) 1			1	
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	Management		
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the	module in detail and take a critical position to them	1.	
Skills	Students are capable of choosing and ap	plying models and methods from the module to indu	ustrial problems.	
Personal Competence				
Social Competence	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineeri	ng: Specialisation II. Product Development and Prod	luction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spe	ecialisation Production and Logistics: Elective Compu	ulsory	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation M	ledical Technology and Control Theory: Elective Com	npulsory	
	Biomedical Engineering: Specialisation M	lanagement and Business Administration: Compulso	ry	
	Product Development, Materials and Prod	duction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Prod	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Prod	duction: Specialisation Materials: Elective Compulsor	ry	
	Theoretical Mechanical Engineering: Spec	cialisation Product Development and Production: Ele	ective Compulsory	
	Theoretical Mechanical Engineering: Tech	hnical 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	ecture	
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	WiSe	
Content	See interlocking course	
Literature	Siehe korrespondierende Vorlesung	
	See interlocking course	

Module M0921: Electi	ronic Circuits fo	or Medical Applic	cations			
Courses						
Title Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl	lications (L1056)			Typ Lecture Recitation Section (small) Practical Course	Hrs/wk 2 1	CP 3 2
Module Responsible				Tractical Course		-
Admission Requirements						
Recommended Previous		trical engineering				
Knowledge		i j				
Educational Objectives	After taking part succ	essfully, students have	reached the following	ng learning results		
Professional Competence						
Knowledge	Students can e Students are al Students can e Students can d Students can e	ble to explain the build- xemplify the communic escribe the special feat xplain the functions of p	up of an action pote ation between neur ures of low-noise an prostheses, e. g. an	ation transfer by the central ential and its propagation alo ons and electronic devices nplifiers for medical applical artificial hand of cochlea implants and arti	ong an axon	
Skills	Students can gStudents can gStudents can g		r improvement of lo ams of prosthetic sy		al acquisition.	
Personal Competence Social Competence	Students are t professional ba Students are a	nckground. ble to recognize their sp document their work in	pecific limitations, so	nedical electronics in team o that they can ask for assis d communicate their results	tance to the right	time.
Autonomy	Students are necessary. Students can b Students can h	reak down their work in andle the complex data	appropriate work p	their knowledge and to de backages and schedule their ectrical experiments without les and situations of experin	work in a realistic	
Workload in Hours	Independent Study Ti	me 124, Study Time in	Lecture 56			
Credit points		Earm	Dec!ti			
Course achievement	Yes None No None	Form Subject theoretical practical work Excercises	Description and			
Examination	Written exam					
Examination duration and						
scale		v Charinlianting Marth 1	Tachnala Flanti	vo Compulson:		
Assignment for the Following Curricula		: Specialisation Medical : Specialisation Medical				
				enerative Medicine: Elective	Compulsory	
	_	-		eses: Elective Compulsory		
	Biomedical Engineering	ng: Specialisation Medic	al Technology and (Control Theory: Compulsory		
				ss Administration: Elective C		
				cs Complements: Elective C		
				ical Technology: Elective Co		
				Course: Elective Compulsory		
	Theoretical Mechanic	ai Engineering: Specialis	sation Bio- and Medi	ical Technology: Elective Co	пригогу	

Course L0696: Electronic Circ	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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 Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g.,	in the module Mechanics II (forces and	I moments, stres	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain er	nergy).		
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to	calculate the mechanical behavior of m	naterials.	
Skills	The students can set up balance laws and apply basic research contexts.	cs of deformation theory to specific as	pects, both in a	pplied contexts as in
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 ar problems in the area of continuum mechanics and acqu	·		wn identify and solve
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Co	mpulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation	on Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Election	ve Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Er	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management ar		mpulsory	
	Product Development, Materials and Production: Core (
	Theoretical Mechanical Engineering: Technical Complete			
	Theoretical Mechanical Engineering: Core Qualification	Elective Compulsory		

Course L1533: Continuum Me	achanics
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: Continuum Mo	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	 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: Mater	rial Modeling	
Courses		
Title	Typ Hrs/wk CP	
Material Modeling (L1535)	Lecture 2 3	
Material Modeling (L1536)	Recitation Section (small) 2 3	
Module Responsible	Prof. Christian Cyron	
Admission Requirements	None	
Recommended Previous	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (fo	rces
Knowledge	and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws	
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowle	edge
	to various problems of material science and evaluate the corresponding material models.	
Personal Competence		
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.	
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and s	olve
	problems in the area of materials modeling and acquire the knowledge required to this end.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination		
Examination duration and	45 min	
scale		
Assignment for the	Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory	
Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory	
	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory	
	Product Development, Materials and Production: Core Qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	

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

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

Module M1199: Adva	nced Functional Materials
Courses	
Title	Typ Hrs/wk CP
Advanced Functional Materials (L16	Seminar 2 6
Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular
	metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design ne
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview of
	modern materials science, which enables them to select optimum materials combinations depending on the technic
	applications.
Personal Competence	
_	The students are able to present solutions to specialists and to develop ideas further.
Social competence	The statents are able to present solutions to specialists and to develop lacus tarafer.
Autonomy	The students are able to
	assess their own strengths and weaknesses.
	gather new necessary expertise by their own.
W. H. H. H.	Indicated State Time 152 State Time Indicate with 20
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Credit points Course achievement	
Examination	
Examination duration and	
scale	30 (1111)
Assignment for the	Materials Science: Core Qualification: Compulsory
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Cha	racterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechani	cs (L1583)	Seminar	2	3
Seminar Biomedical Engineering (I	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				

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

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

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

Course L1588: Development	and Regulatory Approval of Implants	
Тур	ecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	Dr. Roman Nassutt	
Language	DE	
Cycle	WiSe	
Content		
Literature	 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 L1500, Forestimontal	Mathada facilità Characteristica of Matadala
•	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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 Me	thods in Biomechanics
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	 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	schriftliche ausarbeitung und Vortrag (20 min)
scale	
Lecturer	Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	
Literature	Keine

Course L1130: Six Sigma		
Тур	Lecture	
Hrs/wk		
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
Examination duration and	90 Minuten	
scale		
Lecturer	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	

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

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

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

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

Module M1279: MED	II: Introduction to Biochemistry and Molecular Biology
Courses	
Title	Typ Hrs/wk CP
Introduction to Biochemistry and M	Tolecular Biology (L0386) Lecture 2 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	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.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	60 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	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 t	Course L0386: Introduction to Biochemistry and Molecular Biology	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Hans-Jürgen Kreienkamp	
Language	DE	
Cycle	WiSe	
Content		
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage	
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008	

Module M1333: BIO I:	Implants and Fracture Healing
Courses	
Title	Typ Hrs/wk CP
Implants and Fracture Healing (L03	376) Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
Personal Competence	
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	90 min
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics
Following Curricula	Compulsory
	General Engineering Science (German program, 7 semester): 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 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
	Orientierungsstudium: Core Qualification: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0376: Implants and	Fracture Healing
Тур	Lecture
Hrs/wk	2
СР	
	Independent Study Time 62, Study Time in Lecture 28
Language	Prof. Michael Morlock
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
	4. Pelvis (anatomy, biomechanics, fracture treatment)
	5 Fracture Healing
	5.1 Basics and biology of fracture repair
	5.2 Clinical principals and terminology of fracture treatment
	5.3 Biomechanics of fracture treatment
	5.3.1 Screws
	5.3.2 Plates
	5.3.3 Nails
	5.3.4 External fixation devices
	5.3.5 Spine implants
	6.0 New Implants
Literature	Cochran V.B.: Orthopädische Biomechanik
	Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics
	White A.A., Panjabi M.M.: Clinical biomechanics of the spine
	Nigg, B.: Biomechanics of the musculo-skeletal system
	Schiebler T.H., Schmidt W.: Anatomie
	Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat

Module M1334: BIO II	: Biomaterials			
Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical technique	es is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	d the following learning results		
Professional Competence				
Knowledge	The students can describe the materials of the huma	an body and the materials being use	d in medical engineerir	ng, and their fields of
	use.			
Skills	The students can explain the advantages and disadv	vantages of different kinds of biomat	erials	
Skiiis	The students can explain the davantages and disadv	anages of amerene kinds of biolina	ieriais.	
Personal Competence				
Social Competence	The students are able to discuss issues related to m	aterials being present or being used	d for replacements with	student mates and
	the teachers.			
Autonomy	The students are able to acquire information on their	r own. They can also judge the infor	mation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 2	28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Speciali	sation II. Process Engineering and B	iotechnology: Elective (Compulsory
Following Curricula	$\label{eq:Materials} Materials Science: Specialisation Nano and Hybrid Nano and Hybrid Materials Nano and Hybrid Nano And And And And And And And And And And$	aterials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Orga	•	tive Compulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech	• • • • • • • • • • • • • • • • • • • •		
	Biomedical Engineering: Specialisation Management			
	Theoretical Mechanical Engineering: Technical Comp	,	•	
	Theoretical Mechanical Engineering: Specialisation B	io- and Medical Technology: Elective	e Compulsory	

Course L0593: Biomaterials	
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	WiSe Topics to be covered include:
3011311	Introduction (Importance, nomenclature, relations)
	Biological materials
	2.1 Basics (components, testing methods)
	2.2 Bone (composition, development, properties, influencing factors)
	2.3 Cartilage (composition, development, structure, properties, influencing factors)
	2.4 Fluids (blood, synovial fluid)
	3 Biological structures
	3.1 Menisci of the knee joint
	3.2 Intervertebral discs
	3.3 Teeth
	3.4 Ligaments
	3.5 Tendons
	3.6 Skin
	3.7 Nervs
	3.8 Muscles
	4. Replacement materials
	4.1 Basics (history, requirements, norms)
	4.2 Steel (alloys, properties, reaction of the body)
	4.3 Titan (alloys, properties, reaction of the body)
	4.4 Ceramics and glas (properties, reaction of the body)
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)
	4.6 Natural replacement materials
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.
Literature	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.
	Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.

Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polyme		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / material scier	nce		
Educational Objectives	After taking part successfully, students ha	we reached the following learning results		
Professional Competence	Arter taking part successiony, students na	ve reactied the following learning results		
Knowledge	Students can use the knowledge of plastic	s and define the necessary testing and analy	/sis.	
, and medge			, 5.5.	
	They can explain the complex relationship	s structure-property relationship and		
	the interactions of chemical structure of th	ne polymers, including to explain neighboring	g contexts (e.g. sustaina	bility, environment
	protection).			
CI-III-	Shadaaba aa saabla af			
SKIIIS	Students are capable of			
	- using standardized calculation method	s in a given context to mechanical prope	erties (modulus, streng	th) to calculate an
	evaluate the different materials.			
	- selecting appropriate solutions for mech	anical recycling problems and sizing exampl	e stiffness, corrosion re	sistance.
Personal Competence				
Social Competence	Students can			
	- arrive at funded work results in heteroge	nius groups and document them.		
	provide appropriate feedback and bandle	foodback on their own performance constru	rativaly	
	- provide appropriate reedback and fiandle	e feedback on their own performance constru	actively.	
Autonomy	Students are able to			
, ideanon,				
	- assess their own strengths and weakness	ses.		
	- assess their own state of learning in spec	ific terms and to define further work steps o	n this basis.	
		-fiIti-it		
	- assess possible consequences of their pro	oressional activity.		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Materials Science: Specialisation Engineeri	ng Materials: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Imp			
		ificial Organs and Regenerative Medicine: Ele		
		nagement and Business Administration: Elec		
		dical Technology and Control Theory: Electiv action: Specialisation Production: Elective Co		
	·	iction: Specialisation Production: Elective Co iction: Specialisation Materials: Elective Com		
	'	action: Specialisation Product Development:		
	·	nical Complementary Course: Elective Comp		
	Theoretical Mechanical Engineering: Speci	alisation Materials Science: Elective Compuls	sory	

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

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

Caurage					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Rege	nerative Medicine (I 166	54)	Seminar Seminar	2	3 3
Module Responsible					
Admission Requirements					
Recommended Previous					
Knowledge					
Educational Objectives		ccessfully, students have re	eached the following learning results		
Professional Competence		,,			
	After successful cor explain the use of th	he tissue cells for different	udents will be able to describe the ba methods of tissue engineering. They ar		
	the cultivation of an	nimal and human cells.			
		outline the actual concepts of the discussed topics.	ots of Tissue Engineering and regene	erative medicine and co	an explain the bas
Skills	After successful con	mpletion of the module stud	dents 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 defend them.		with 2-4 students to solve given tasks and discuss it with other students and te		in the plenary and
Autonomy	After completion o	of this module, participan ding a presentation of the	ts will be able to solve a technical results.	problem in teams of	approx. 2-4 persoi
Workload in Hours	Independent Study	Time 124, Study Time in Le	ecture 56		
Credit points		•			
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / p	protocol for lecture series	5
Examination	Presentation				
Examination duration and	· ·	discussion (30 min)			
	1				
Scale	Riomedical Engineer	ring: Specialization Implan	ts and Endonrostheses: Elective Comp	deory	
Assignment for the	_	• .	ts and Endoprostheses: Elective Compu	•	
	Biomedical Engineer	ring: Specialisation Artificia	ts and Endoprostheses: Elective Compu al Organs and Regenerative Medicine: C ement and Business Administration: Ele	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	e Engineering - Regenerative Medicine
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Michael Morlock
Language	DE
Cycle	WiSe
Content	Discussion of current research topics for tissue engineering and regenerative medicine by invited experts
Literature	Regenerative Biology and Medicine (Taschenbuch) von David L. Stocum; Academic Pr Inc; ISBN-10: 0123693713 , ISBN-13: 978-0123693716
	Fundamentals of Tissue Engineering and Regenerative Medicine von Ulrich Meyer (Herausgeber), Thomas Meyer (Herausgeber), Jörg Handschel (Herausgeber), Hans Peter Wiesmann (Herausgeber): Springer, Berlin; ISBN-10: 3540777547; ISBN-13: 978-3540777540

Courses				
Title		Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and		Lecture	3	5
Bioelectromagnetics: Principles and		Recitation Section (small)	2	1
	Prof. Christian Schuster			
Admission Requirements				
Kecommended Previous Knowledge	Basic principles of physics			
imomougo				
Educational Objectives	After taking part successfully students h	ave reached the following learning results		
Professional Competence	The taking part saccessiany, stadents in	ave reaction the following realting results		
•	Students can explain the basic principles	, relationships, and methods of bioelectromagnetic	s, i.e. the guantific	ation and applicati
		ssue. They can define and exemplify the most imp		
	them corresponding to wavelength and	frequency of the fields. They can give an overv	iew over measure	ment and numerio
	techniques for characterization of electr	omagnetic fields in practical applications . They o	can give examples	for therapeutic a
	diagnostic utilization of electromagnetic	fields in medical technology.		
Skills		hods to characterize the behavior of electromagnet	_	
		e of the elementary solutions of Maxwell's Equation		
		edict for biological tissue, they can order the effe		
		nalyze them in a quantitative way. They are able to	•	-
	·	e effects of electromagnetic fields for therapeutic a	nd diagnostic appl	ications and make
	appropriate choice.			
Personal Competence				
•	Students are able to work together on s	subject related tasks in small groups. They are abl	e to present their	results effectively
Social competence	English (e.g. during small group exercise		e to present then	results effectively
Autonomy	Students are capable to gather informa	ation from subject related, professional publicatio	ns and relate tha	t information to t
	context of the lecture. They are able to	make a connection between their knowledge obta	ined in this lecture	e with the content
	other lectures (e.g. theory of electroma	gnetic fields, fundamentals of electrical engineer	ing / physics). The	ey can communica
	problems and effects in the field of bioele	ectromagnetics in English.		
Workload in Hours	Independent Study Time 110, Study Time	e in Lecture 70		
Credit points	6	Descriptio-		
Course achievement	Compulsory Bonus Form Yes 10 % Presentation	Description		
Examination	Oral exam			
Examination duration and	45 min			
scale	.5			
Assignment for the	Electrical Engineering: Specialisation Med	, ,		
Following Curricula		rowave Engineering, Optics, and Electromagnetic C		ive Compulsory
	-	ng: Specialisation II. Electrical Engineering: Elective		
		rtificial Organs and Regenerative Medicine: Elective	Compulsory	
		aniants and Endoprosthosos, Elective Compulsory		
	Biomedical Engineering: Specialisation In			
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Elective Cor		
	Biomedical Engineering: Specialisation M Biomedical Engineering: Specialisation M		Compulsory	

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

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

Module M0630: Robot	tics and Naviga	ntion in Medi	cine			
Courses						
Title Robotics and Navigation in Medicin	e (L0335)			Typ Lecture	Hrs/wk	CP
Robotics and Navigation in Medicin				Project Seminar	2	2
Robotics and Navigation in Medicin				Recitation Section (small)	1	1
Module Responsible		efer				
Admission Requirements	None					
Recommended Previous	 principles of m 	nath (algebra, anal	ysis/calculus)			
Knowledge	principles of psolid R or Matl	rogramming, e.g., ab skills	in Java or C++			
Educational Objectives	After taking part succ	cessfully, students	have reached the follow	ing learning results		
Professional Competence						
	detail. Systems can systems regarding de	be evaluated with	n respect to collision de ons.	clinical contexts and illustrate tection and safety and reg	ulations. Student	s can assess typical
Personal Competence	The students discuss	the results of other	er groups, provide helpfu	Il feedback and can incoorpor	ate feedback into	their work.
Workload in Hours	Independent Study T	ime 110. Study Tir	ne in Lecture 70			
Credit points		inc 110, Study III	ne iii Eccture 70			
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Presentation				
	Yes 10 %	Written elaborat	ion			
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: S	pecialisation Intelli	gence Engineering: Elec	tive Compulsory		
Following Curricula	Electrical Engineering	g: Specialisation M	edical Technology: Elect	ive Compulsory		
	International Manage	ement and Enginee	ring: Specialisation II. El	ectrical Engineering: Elective	Compulsory	
	Mechatronics: Specia	llisation Intelligent	Systems and Robotics: E	Elective Compulsory		
	Biomedical Engineeri	ng: Specialisation	Artificial Organs and Reg	generative Medicine: Elective	Compulsory	
	_			neses: Elective Compulsory		
				Control Theory: Elective Com		
	_		•	ess Administration: Elective Co		
				Product Development: Electiv		
			•	Production: Elective Compuls	•	
				Materials: Elective Compulsor	У	
				Course: Elective Compulsory dical Technology: Elective Cor	mnulsory	
	corected Mechanic	.a. Ingiliceting. Jp	Columbation Dio- and Met	a.ca. recimiology. Licetive Col		

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

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

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

Module M0634: Introd	duction into Me	dical Technology a	and System	ıs		
Courses						
Title				Тур	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)				Lecture	2	3
Introduction into Medical Technolog				Project Seminar	2	2
Introduction into Medical Technolog	gy and Systems (L1876)			Recitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlae	efer				
Admission Requirements	None					
Recommended Previous	principles of math (alg	gebra, analysis/calculus)				
Knowledge	principles of stochast	ics				
	principles of programi	ming, R/Matlab				
Educational Objectives	After taking part succ	essfully, students have rea	ched the following	ng learning results		
Professional Competence						
Knowledge	The students can ex	plain principles of medica	technology, in	cluding imaging systems, c	omputer aided s	urgery, and medical
	information systems.	They are able to give an ov	erview of regula	atory affairs and standards in	medical technolo	ogy.
Skills	The students are able	to evaluate systems and n	nedical devices i	n the context of clinical appl	ications	
55	The seadones are asie	to evaluate systems and n	.ca.ca. acricco	in the context of chinear app.	.cacionisi	
Personal Competence						
Social Competence	The students describe	a problem in medical tech	nology as a proj	ect, and define tasks that are	e solved in a joint	effort.
Autonomy	The students can refle	ect their knowledge and do	ocument the res	sults of their work. They can	present the resu	Its in an appropriate
,	manner.	, and the second		,		
			7.0			
Workload in Hours		me 110, Study Time in Lect	ture 70			
Credit points	6	F	D			
Course achievement	Compulsory Bonus Yes 10 %	Form Written elaboration	Description			
	Yes 10 %	Presentation				
Examination	Written exam	. resemuation				
Examination duration and	90 minutes					
scale						
Assignment for the	General Engineering S	Science (German program,	7 semester): Sp	ecialisation Biomedical Engir	eering: Compulso	ory
Following Curricula	Computer Science: Sp	ecialisation Computer and	Software Engine	eering: Elective Compulsory		
	Electrical Engineering	: Core Qualification: Electiv	e Compulsory			
	General Engineering S	Science (English program, 7	semester): Spe	cialisation Biomedical Engine	eering: Compulso	ry
	Computational Science	e and Engineering: Special	sation II. Mathe	matics & Engineering Science	e: Elective Compu	ılsory
	Computational Science	e and Engineering: Special	sation Compute	r Science: Elective Compulso	ory	
	Computational Science	e and Engineering: Special	isation Engineer	ing Sciences: Elective Compu	ulsory	
	Biomedical Engineering	ng: Specialisation Artificial (Organs and Rege	enerative Medicine: Elective	Compulsory	
	-	ng: Specialisation Implants	•			
	_			Control Theory: Elective Com		
	-	• .		ss Administration: Elective Co	ompulsory	
	Technomathematics:	Specialisation III. Engineeri	ng Science: Elec	tive Compulsory		

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the	ne following learning results		
Professional Competence				
	Students are able to reflect existing terms and conc concepts. Students are able to apply existing methods and proce-		·	
Personal Competence	Students are able to apply existing methods and proces	sures of Northhear Dynamics and to	develop novel meth	lous and procedures.
·	Students can reach working results also in groups.			
,	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				
-	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Sy	stems: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisat	tion II. Mechatronics: Elective Comp	ulsory	
	Mechanical Engineering and Management: Specialisation	on Mechatronics: Elective Compulso	ry	
	Mechatronics: Specialisation System Design: Elective C	ompulsory		
	Mechatronics: Specialisation Intelligent Systems and Ro	obotics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	•		
	Biomedical Engineering: Specialisation Management ar		Compulsory	
	Product Development, Materials and Production: Core (•		
	Theoretical Mechanical Engineering: Technical Complete	· ·	у	
	Theoretical Mechanical Engineering: Core Qualification:	Elective Compulsory		

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

Courses				
Title		Тур	Hrs/wk	CP .
Semiconductor Technology (L0722 Semiconductor Technology (L0723		Lecture Practical Course	4 2	4
Module Responsible				
Admission Requirements				
Recommended Previous		semiconductor devices		
Knowledge	, , , , , , , , , , , , , , , , , , , ,			
Educational Objectives	After taking part successfully, students have reache	ed the following learning results		
Professional Competence				
Knowledge				
	Students are able			
	to describe and to explain current fabrication to	echniques for Si and GaAs substrates,		
	to discuss in details the relevant fabrication	tion processes, process flows and t	the impact thereof o	n the fabrication
	semiconductor devices and integrated circuits and			
	to present integrated process flows.			
	to present meegrated process nons.			
Skills				
	Students are canable			
	Students are capable			
	to analyze the impact of process parameters o	n the processing results,		
	to select and to evaluate processes and			
	to develop process flows for the fabrication of s	semiconductor devices.		
Personal Competence				
Social Competence				
bociai competence				
	Students are able to prepare and perform their lab	experiments in team work as well as	to present and discus	ss the results in fro
	of audience.			
Autonomy	None			
	Independent Study Time 96, Study Time in Lecture	84		
Credit points				
Course achievement				
Examination	Oral exam			
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectroni	cs and Microsystems Technology, Elo	ctive Compulsory	
Following Curricula				
. July ming curricula	Biomedical Engineering: Specialisation Implants an	,	, ,	
	Biomedical Engineering: Specialisation Medical Tec			
	Biomedical Engineering: Specialisation Managemer	•		
	Microelectronics and Microsystems: Specialisation I	Microelectronics Complements: Electiv	ve Compulsory	

Course L0722: Semiconducto	or Technology
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Hoc Khiem Trieu
Language	
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, EUV lithography, ion beam lithography, wet chemical etching: isotropic and anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etching, backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk CP	
Humanoid Robotics (L0663)		Seminar	2 2	
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have read	ched the following learning results		
Professional Competence				
Knowledge	Students can explain humanoid robots.			
	Students learn to apply basic control concerns.	epts for different tasks in humanoid r	obotics.	
Skills	Students acquire knowledge about selecte	d aspects of humanoid robotics, base	ed on specified literature	
	Students generalize developed results and	present them to the participants		
	Students practice to prepare and give a pr	esentation		
Danis and Commentaries				
Personal Competence Social Competence				
Social Competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	 They are able to provide appropriate feed! 	back and handle constructive criticism	n of their own results	
Autonomy				
Autonomy	 Students evaluate advantages and draw 	backs of different forms of present	ation for specific tasks and select the I	
	solution			
	 Students familiarize themselves with a so 	ientific field, are able of introduce it	and follow presentations of other stude	
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lectu	re 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Systems	and Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Elec	tive Compulsory		
	Biomedical Engineering: Specialisation Artificial C	Organs and Regenerative Medicine: E	lective Compulsory	
	Biomedical Engineering: Specialisation Implants	·		
	Biomedical Engineering: Specialisation Medical T	•		
	Biomedical Engineering: Specialisation Managem			
	Theoretical Mechanical Engineering: Technical Co		ulsory	
	Theoretical Mechanical Engineering: Core Qualific	cation: Elective Compulsory		

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

	fikation		
	Typ	Hrs/wk	СР
fication (L0660)	Lecture	2	3
Prof. Herbert Werner			
None			
 State space methods Discrete-time systems Linear algebra, singular value decomp	position		
After taking part successfully, students have	reached the following learning results		
nonlinear model structures They can explain how multilayer perce They can explain how an approximate They can explain the idea of subspace Students are capable of applying the models for dynamic systems They are capable of implementing a new they are capable of applying subspace They can do the above using standard Students can work in mixed groups on specifications.	eptron networks are used to model nonline e predictive control scheme can be based of e identification and its relation to Kalman re e predicition error method to the experimental onlinear predictive control scheme based of e algorithms to the experimental identifical software tools (including the Matlab System).	ar dynamics In neural network model Is alisation theory In neural identification of In a neural network model It is a neu	linear and nonlinea del dynamic systems x)
solve given problems.			
	ecture 28		
30 min			
Electrical Engineering: Specialisation Control	and Power Systems Engineering: Elective	Compulsory	
Mechatronics: Specialisation Intelligent Syste	ems and Robotics: Elective Compulsory		
Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Mana Theoretical Mechanical Engineering: Technic	cial Organs and Regenerative Medicine: Ele ints and Endoprostheses: Elective Compuls cal Technology and Control Theory: Compu gement and Business Administration: Elect al Complementary Course: Elective Compu	ory Isory tive Compulsory	
	State space methods Discrete-time systems Linear algebra, singular value decompessory Basic knowledge about stochastic pro After taking part successfully, students have Students can explain the general franconlinear model structures They can explain how multilayer percessory They can explain how an approximate They can explain the idea of subspaces Students are capable of applying the models for dynamic systems They are capable of implementing and They are capable of applying subspaces They can do the above using standard Students can work in mixed groups on specific students are able to find required informations solve given problems. Independent Study Time 62, Study Time in Legional standard Mone Oral exam Mechatronics: Specialisation Intelligent System Mechatronics: Specialisation Intelligent System Design: Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Mana Theoretical Mechanical Engineering: Technic	Prof. Herbert Werner None Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method an nonlinear model structures They can explain how multilayer perceptron networks are used to model nonline They can explain how an approximate predictive control scheme can be based o They can explain the idea of subspace identification and its relation to Kalman re Students are capable of applying the prediction error method to the experim models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based o They are capable of applying subspace algorithms to the experimental identifica They can do the above using standard software tools (including the Matlab System) Students can work in mixed groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literated) They can do the above using standard software tools (including the Matlab System) Students are able to find required information in sources provided (lecture notes, literated) They can do the above using standard software tools (including the Matlab System) Students are able to find required information in sources provided (lecture notes, literated) They can do the above using standard software tools (including the Matlab System) Students are able to find required information in sources provided (lecture notes, literated) Students are able to find required information and Power Systems Engineering: Elective Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation	Prof. Herbert Werner None Classical control (frequency response, root locus) State space methods Discrete-time systems Linear algebra, singular value decomposition Basic knowledge about stochastic processes After taking part successfully, students have reached the following learning results Students can explain the general framework of the prediction error method and its application to a 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 model They can explain how an approximate predictive control scheme can be based on neural network model on they can explain the idea of subspace identification and its relation to Kalman realisation theory Students are capable of applying the predicition error method to the experimental identification of models for dynamic systems They are capable of implementing a nonlinear predictive control scheme based on a neural network model on the above using standard software tools (including the Matlab System Identification Toolbo They can do the above using standard software tools (including the Matlab System Identification Toolbo They can do the above using standard software tools (including the Matlab System Identification Toolbo Toolbo Students can work in mixed groups on specific problems to arrive at joint solutions. Students are able to find required information in sources provided (lecture notes, literature, software documents of the solution

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

- Taulo Floo-tor optili	nal and Robust Control			
Courses				
Fitle Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible		recitation section (smail)	-	
Admission Requirements				
Recommended Previous Knowledge	Classical control (frequency response, root State space methods Linear algebra, singular value decompositi			
Educational Objectives	After taking part successfully, students have read	thed the following learning results		
Professional Competence Knowledge	 Students can explain the significance of th They can explain the duality between optin They can explain how the H2 and H-infinity They can explain how an LQG design problem They can explain how model uncertainty of the control of the smale and uncertain plant. They understand how analysis and synthes Students are capable of designing and tun They are capable of representing a H2 or H software tools for solving it. They are capable of translating time and sensitivity functions, and of carrying out a They are capable of constructing an LFT robust controller. They are capable of formulating analysis a LMI-solvers for solving them. They can carry out all of the above using s 	mal state feedback and optimal state estimal rooms are used to represent stability and plem can be formulated as special case of an can be represented in a way that lends itself all gain theorem - a robust controller can guistis conditions on feedback loops can be repring LQG controllers for multivariable plant methininity design problem in the form of a geoffrequency domain specifications for control mixed-sensitivity design. Uncertainty model for an uncertain system and synthesis conditions as linear matrix incompared.	tion. performance cons H2 design proble to robust control arantee stability esented as linear odels. neralized plant, a loops into const , and of designin equalities (LMI), a	m. ler design and performance matrix inequalitie and of using standa raints on closed-la
Personal Competence				
Social Competence	Students can work in small groups on specific pro	oblems to arrive at joint solutions.		
Autonomy			software docume	ntation) and use it
Workload in Hours	Independent Study Time 124, Study Time in Lect	ure 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the	Computer Science: Specialisation Intelligence Eng	gineering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Control and	Power Systems Engineering: Elective Comp	ulsory	
	Energy Systems: Core Qualification: Elective Com	pulsory		
	Aircraft Systems Engineering: Specialisation Aircr	raft Systems: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems	·		
	Mechatronics: Specialisation System Design: Elec		C	
	Biomedical Engineering: Specialisation Artificial C	•	Compulsory	
	Biomedical Engineering: Specialisation Implants a Biomedical Engineering: Specialisation Medical Te		nulsory	
	Biomedical Engineering: Specialisation Medical To	•		
	Product Development, Materials and Production:			
	Product Development, Materials and Production:	·		
	Product Development, Materials and Production:	Specialisation Materials: Elective Compulsor	y	
	Theoretical Mechanical Engineering: Technical Co	emplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualific	cation: Elective Compulsory		

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

Module M0855: Marko	eting (Sales and Services / Innovatio	n Marketing)		
Courses				
Title		Тур	Hrs/wk	СР
Marketing of Innovations (L2009)		Lecture	4	4
PBL Marketing of Innovations (L086	52)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous	Module International Business			
Knowledge	Basic understanding of business administrate	ion principles (strategic planning, decisi	on theory, pr	oject management,
	international business)			
	Bachelor-level Marketing Knowledge (Marketing		egies, Basics o	of Buying Behavior)
	 Unerstanding the differences beweetn B2B and Understanding of the importance of managing 			
	Good English proficiency; presentation skills	illiovation in global illudstrial markets		
	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of inno	vative poroducts and services		
	Approaches for analyzing the current market si		İ	
	The gathering of information about future custo			
	 Concepts and approaches to integrate lead use Approaches and tools for ensuring customer-or 			-
	Marketing mix elements that take into consider			
	services	·	3	·
	 Pricing methods for new products and services 			
	The organization of complex sales forces and p	ersonal selling		
	Communication concepts and instruments for r	ew products and services		
Skills	Based on the acquired knowledge students will be ab	e to:		
	Design and to evaluate decisions regarding ma	rketing and innovation strategies		
	 Analyze markets by applying market and techr 	ology portfolios		
	Conduct forecasts and develop compelling scel			
	Translate customer needs into concepts, proto	**	ully apply adv	anced methods for
	 customer-oriented product and service develop Use adequate methods to foster efficient diffus 			
	Choose suitable pricing strategies and communications			
	Make strategic sales decisions for products and	services (i.e. selection of sales channels)		
	Apply methods of sales force management (i.e.)	customer value analysis)		
Personal Competence				
· ·	The students will be able to			
	have finished discussions and such as a such			
	 have fruitful discussions and exchange argume develop original results in a group 	nts		
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
	Acquire knowledge independently in the specification.	c context and to man this knowledge on ot	her new comp	lev problem fields
	Consider proposed business actions in the field	,	nei new compi	ex problem neids.
	Independent Study Time 110, Study Time in Lecture 7	0		
Credit points				
Course achievement				
Examination Examination duration and	Subject theoretical and practical work Written elaboration, excercises, presentation, oral particular particular properties of the proper	ticination		
scale	whitem elaboration, excercises, presentation, oral pal	delpation		
Assignment for the	Global Technology and Innovation Management & Ent	repreneurship: Core Qualification: Compuls	ory	
Following Curricula	**		-	
	Mechanical Engineering and Management: Specialisat			
	Biomedical Engineering: Specialisation Artificial Organ		npulsory	
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techn		ory	
	Biomedical Engineering: Specialisation Management a	ina basiness Auministration: Compaisory		

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	I. Introduction
Content	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
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 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

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

Module M1143: Mech	anical Design Methodology			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Design Methodology (L	1523)	Lecture	3	4
Mechanical Design Methodology (L.	1524)	Recitation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Science-based working on product design co	nsidering targeted application of specific prod	luct design techniqu	es
Skille	Creative handling of processes used for scien	atific preparation and formulation of complex	product design prob	Jame / Application of
Skills	various product design techniques following		product design proc	nems / Application of
	various product design teeningdes following	incoretical aspects.		
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Product Development and Pr	oduction: Elective Co	ompulsory
Following Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artific	ial Organs and Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Impla	nts and Endoprostheses: Elective Compulsory	1	
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Mana	gement and Business Administration: Elective	e Compulsory	
	Theoretical Mechanical Engineering: Specialis	sation Product Development and Production:	Elective Compulsory	
	Theoretical Mechanical Engineering: Technic	al Complementary Course: Elective Compulso	ry	

Course L1523: Mechanical Do	esign 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 Do	esign 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

Courses				
Title		Тур	Hrs/wk	CP
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible				
Admission Requirements				
	none, module "organic chemistry", module	"fundamentals for process engineering"		
Knowledge				
Educational Objectives	,	re reached the following learning results		
Professional Competence Knowledge	Students are able to describe the basic cor enzymes and microorganisms, as well as rheology can be named and mass transp	ncepts of bioprocess engineering. They are able to differentiate different types of inhibition. For the processes in bioreactors can be explained illization technology and downstream processing	The parameters of	of stoichiometry a
Skills	 After successful completion of this module, students should be able to describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microato compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner 		wth inhibition on t	
Personal Competence Social Competence Autonomy	After completion of this module participant take position to their own opinions and incr	es should be able to debate technical questions rease their capacity for teamwork in engineering as will be able to solve a technical problem in a blenum.	and scientific envi	ronments.
Workload in Hours	Independent Study Time 96, Study Time in	Lecture 84		
Credit points				
Course achievement	Yes 5 % Subject theoretical practical work	Description al and		
Examination				
Examination duration and scale				
Assignment for the	General Engineering Science (German prog	ram, 7 semester): Specialisation Process Engine	ering: Compulsory	
Following Curricula		ram, 7 semester): Specialisation Bioprocess Eng		
	Bioprocess Engineering: Core Qualification:	Compulsory		
-	General Engineering Science (English progr	ram, 7 semester): Specialisation Process Engine	ering: Compulsory	
-	General Engineering Science (English progr	_	neering: Compulso	
		am, 7 semester): Specialisation Bioprocess Engi	meering. Compaiso	ry
-	General Engineering Science (English progr	ram, 7 semester): Specialisation Bioprocess Engi ficial Organs and Regenerative Medicine: Compu		ry
-	General Engineering Science (English progr Biomedical Engineering: Specialisation Artif	ficial Organs and Regenerative Medicine: Compu		ry
-	General Engineering Science (English progr Biomedical Engineering: Specialisation Artif Biomedical Engineering: Specialisation Impl	ficial Organs and Regenerative Medicine: Compulants and Endoprostheses: Elective Compulsory	ılsory	ry
-	General Engineering Science (English progr Biomedical Engineering: Specialisation Artif Biomedical Engineering: Specialisation Impl Biomedical Engineering: Specialisation Med	ficial Organs and Regenerative Medicine: Compu lants and Endoprostheses: Elective Compulsory lical Technology and Control Theory: Elective Co	mpulsory	ry
	General Engineering Science (English progr Biomedical Engineering: Specialisation Artif Biomedical Engineering: Specialisation Impl Biomedical Engineering: Specialisation Med	ficial Organs and Regenerative Medicine: Compulants and Endoprostheses: Elective Compulsory lical Technology and Control Theory: Elective Colagement and Business Administration: Elective	mpulsory	ry

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, 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 En	gineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

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

Module M1280: MED	II: Introduction to Physiology		
Courses			
Title	Тур Ні	rs/wk	СР
Introduction to Physiology (L0385)	Lecture 2		3
Module Responsible	Dr. Roger Zimmermann		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can		
	describe the basics of the energy metabolism;		
	describe the basics of the energy metabolism, describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sense.	sory physiole	an
	- describe physiological relations in selected fields of master, field with the and sens	ory priyatore	
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing	ig of informa	ation, developmen
	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 metrologic	:al.	
Autonomy	The students can derive answers to questions arising in the course and other physiological areas	. usina tech	nnical literature. b
,	themselves.	,	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and	60 minutes		
scale			
Assignment for the			
Following Curricula		neering, Fo	cus Biomechanics
	Compulsory		
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engir	neering, Foo	cus Biomechanic
	Compulsory	C	
	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 Management and Business Administration: Elective Compulsors Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsors	•	
		SUI Y	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory		

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

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

avT	Lecture	
Hrs/wk		
СР		
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Lange	
Language	DE	
Cycle		
Content	General Anatomy	
	1 st week:	The Eucaryote Cell
	2 nd week:	The Tissues
	Z*** 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
	7 th week:	Genito-urinary System
	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/Michael	Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

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

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1332: BIO I:	Experimental Methods in Biomech	nanics		
Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implantate un	nd Frakturheilung" before attending "	Experimentelle Methode	n".
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how	bones heal, and the requirements fo	r their existence.	
	The students can name different treatments for th	e spine and hollow bones under give	n fracture morphologies.	
	The students can describe different measurement	techniques for forces and movemen	ts, and choose the adequ	uate technique for a
	given task.	teeques ioi ioi ees una movemen	is, and enouse are adeq.	aate teemiiqae ioi a
	3			
Skills	The students can describe the basic handling of se	everal experimental techniques used	in biomechanics.	
Personal Competence				
_	The students can, in groups, solve basic experime	ntal tasks.		
Autonomy	The students can, in groups, solve basic experime	ntal tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture	28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program	, 7 semester): Specialisation Mec	hanical Engineering, Fo	ocus Biomechanics:
Following Curricula	Compulsory			
	General Engineering Science (German program, 7	semester): Specialisation Biomedical	Engineering: Compulsor	ry
	General Engineering Science (English program	, 7 semester): Specialisation Med	hanical Engineering, Fo	ocus Biomechanics:
	Compulsory			
	General Engineering Science (English program, 7 s		Engineering: Compulsor	у
	Mechanical Engineering: Specialisation Biomechan		all a Constant	
	Biomedical Engineering: Specialisation Artificial Or			
	Biomedical Engineering: Specialisation Implants ar	·	•	
	Biomedical Engineering: Specialisation Medical Tec	•		
	Biomedical Engineering: Specialisation Manageme Technomathematics: Specialisation III. Engineering		Live Cumpuisury	
	recinionathematics. Specialisation III. Engineering	g Science. Liective Compuisory		

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: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techn	iques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have read	hed the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds of arti	ficial limbs.		
CI:II-	The students can explain the advantages and dis	- d		
SKIIIS	The students can explain the advantages and dis	advantages of different kinds of endop	rotneses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to	endoprothese with student mates and	I the teachers.	
Autonomy	The students are able to acquire information on t	heir own. They can also judge the infor	mation with respect to	its cradibility
Autonomy	The students are able to dequire information on t	nen own. They can also judge the infor	mation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lectu	re 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Spec	ialisation II. Process Engineering and B	iotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid	d Materials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial C	organs and Regenerative Medicine: Elec	ctive Compulsory	
	Biomedical Engineering: Specialisation Implants a	and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical To	echnology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Managem	ent and Business Administration: Electi	ive Compulsory	
	Orientierungsstudium: Core Qualification: Elective	e Compulsory		
	Theoretical Mechanical Engineering: Technical Co	emplementary Course: Elective Compul	sory	
	Theoretical Mechanical Engineering: Specialisation	n Bio- and Medical Technology: Electiv	e Compulsorv	

Typ Lecture Hrs/wk 2 CP 3 Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecturer Prof. Michael Morlock Language DE Cycle SoSe Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Gelenkersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelenkersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecturer Prof. Michael Morlock Language DE Cycle SoSe Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelenkersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
Workload in Hours Independent Study Time 62, Study Time in Lecture 28 Lecturer Prof. Michael Morlock Language DE Cycle SoSe Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
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Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelenkersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
Content Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
Content Inhalt (deutsch) 1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes) 2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität) 3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate) 4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten) 5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren) 6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz) 7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)
 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)
 BIE 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: Feedl	oack Control in Medical Tech	inology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals in human physiology will be similarly introduced like knowledge in control theory.		w. Fundamentals in	
	Internal control loops of the human body will be discussed in the same way like the design of external closed loop system for example in for anesthesia control.			osed loop system fo
	The handling of PID controllers and mo illustrated. The operation of simple equiv	odern controller like predictive controller or fu valent circuits will be discussed.	zzy controller or neu	ral networks will be
Skills	Application of modeling, identification, co	ontrol technology in the field of medical technolo	gy.	
Personal Competence Social Competence	Students can develop solutions to specifi	c problems in small groups and present their res	ults	
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluate their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.		•	
Workload in Hours	Independent Study Time 62, Study Time	in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Med	dical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Cor	ntrol and Power Systems Engineering: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsor	У	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Electiv	e Compulsory	
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Compulso	ory	

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

Title Typ Hrs/wk CP Advanced Topics in Control (L0661) Lecture 2 3	Module M0832: Advai	nced Topics in Control			
Advanced Topics in Control (1982) Modula Responsible Perk Interest Wemen Recommended Previous Harriffing uptimal control, mised semakhily design, linear matrix inequalities Roweldage Educational Objectives Anoweldage Educational Objectives Anoweldage Foressional Competence Anoweldage State of the Competence of the Competenc	Courses				
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Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				pulsory	
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Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory		Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective	Compulsory	
		Theoretical Mechanical Engineering: Technical Complete	mentary Course: Elective Compulsory		

Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Typ	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
	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	a Warner III Lecture Notes "Advanced Taxics in Controll"
	Werner, H., Lecture Notes "Advanced Topics in Control"

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

Specialization Artificial Organs and Regenerative Medicine

Module M0623: Intell	igent Systems i	in Medicine				
Courses						
				Tree	Line /u.le	CD
Title Intelligent Systems in Medicine (L0	331)			Typ Lecture	Hrs/wk 2	CP 3
Intelligent Systems in Medicine (L0				Project Seminar	2	2
Intelligent Systems in Medicine (L0				Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous Knowledge	 principles of st 	ogramming, Java/C++ ar				
Educational Objectives	After taking part succ	essfully, students have re	eached the following	g learning results		
Professional Competence						
Knowledge Skills	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 disadvantage in clinical contexts. The students can compare different methods for representing medical knowledge. They can evaluate method in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition and due to privace and safety requirements. The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can asses the methods based on actual patient data and evaluate the implemented methods.					
Personal Competence Social Competence	The students discuss	the results of other group	os, provide helpful f	eedback and can incoorpo	orate 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 Ti	me 110, Study Time in Le	ecture 70			
Credit points	6					
Course achievement	Yes 10 %	Form Written elaboration Presentation	Description			
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: Sp	ecialisation Intelligence	Engineering: Electiv	re Compulsory		
Following Curricula	Computational Science Mechatronics: Specia Biomedical Engineerie Biomedical Engineerie Biomedical Engineerie Biomedical Engineerie Theoretical Mechanic	lisation Intelligent System ng: Specialisation Artificia ng: Specialisation Implant ng: Specialisation Medica ng: Specialisation Manage al Engineering: Technical	alisation Systems E as and Robotics: Ele al Organs and Reger as and Endoprosthes I Technology and Co ement and Business Complementary Co	ingineering and Robotics:	e Compulsory mpulsory Compulsory	у

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

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

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	d Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
	(goals, utilities, environments). They can descan be discussed in terms of decision proble world scenarios, students can summarize her formalism in static and dynamic settings. In settings, with and with complete access to solving (partially observable) Markov decisions Students can identify techniques for simulate desired states. Students can explain coording of equilibria, social choice functions, voting pure Students can select an appropriate agent a students can derive decision trees and apply networks/dynamic Bayesian networks and different sampling techniques for simplified best action or policies for concrete settings.	define intelligence in terms of rational behavior, scribe the main features of environments. The notems and algorithms for solving these problems. We Bayesian networks can be employed as a known addition, students can define decision making the state of the environment. In this context, so problems, and they can recall techniques for an encous localization and mapping, and can explain action problems and decision making in a multi-action scenary basic optimization techniques. For those application scenary basic optimization techniques. For those application scenarios agent scenarios. For simple and complex decision multi-agent situations students will apply different voting the state of the multi-agent situations students will apply different voting the multi-action of the multi-action making students will apply different voting the multi-action of the multi-	tion of adversariation of adve	al agent cooperate uncertainty in restation and reason mple and sequen cribe techniques value of informatiniques for achieverm of different typed agent applicated as create Bayes on name and applicts can compute g different equilibit
Personal Competence				
	Students are able to discuss their solutions to			
Social Competence		o problems with others. They communicate in Eng	glish	
		o problems with others. They communicate in Englanding of complex concepts by solving varaints of		าร
	Students are able of checking their understa	nding of complex concepts by solving varaints of		าร
Autonomy	Students are able of checking their understar	nding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours	Students are able of checking their understar Independent Study Time 124, Study Time in 6	nding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understar Independent Study Time 124, Study Time in 6	nding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam	nding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam	nding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination Examination and	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam 90 minutes	nding of complex concepts by solving varaints of		ns
Workload in Hours Credit points Course achievement Examination Examination and scale	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	nding of complex concepts by solving varaints of	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	e Engineering: Elective Compulsory Specialisation II. Information Technology: Elective	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cou. Biomedical Engineering: Specialisation Artifice	e Engineering: Elective Compulsory Specialisation II. Information Technology: Elective rise: Elective Compulsory and Organs and Regenerative Medicine: Elective Compulsory	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cou. Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla	e Engineering: Elective Compulsory Specialisation II. Information Technology: Elective rise: Elective Compulsory and Organs and Regenerative Medicine: Elective Conts and Endoprostheses: Elective Compulsory	concrete problen e Compulsory Compulsory	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understar Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cou. Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medical Engineering: Specialisation Medical Engineering: Specialisation Medical	e Engineering: Elective Compulsory Specialisation II. Information Technology: Elective irse: Elective Compulsory ial Organs and Regenerative Medicine: Elective Conts and Endoprostheses: Elective Compulsory al Technology and Control Theory: Elective Compulsory	concrete problen e Compulsory Compulsory	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Coulision Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic Biomedical Engineering: Specialisation Mana	e Engineering: Elective Compulsory Specialisation II. Information Technology: Elective rise: Elective Compulsory and Organs and Regenerative Medicine: Elective Conts and Endoprostheses: Elective Compulsory	concrete problen e Compulsory Compulsory	ns

Course L0341: Intelligent Au	tonomous Agents and Cognitive Robotics
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
	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 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
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 (L16	563)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)		Recitation Section (small)	2	2
Development and Regulatory Appre	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
-	Biomedical Engineering: Specialisation Management a	•		

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

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

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

Course L1588: Development	and Regulatory Approval of 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	90 Minuten	
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	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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).

Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Klausur	
xamination duration and	90 Minuten	
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 Biom	ourse L1890: Seminar Biomedical Engineering	
Тур	Seminar	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Examination Form	Referat	
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
Lecturer	Prof. Michael Morlock	
Language	DE	
Cycle	WiSe	
Content		
Literature	Keine	

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	90 Minuten	
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	

₩	Lactura	
	Lecture	
	4	
	Independent Study Time 92, Study Time in Lecture 28	
Examination Form	Klausur	
xamination duration and		
scale		
Lecturer	Prof. Michael Schlüter	
Language	DE	
Cycle	WiSe	
Content		
	Differential equations for momentum-, heat and mass transfer	
	Examples for simplifications of the Navier-Stokes Equations	
	Unsteady momentum transfer	
	Free shear layer, turbulence and free jets Flavoration of this Process Facility Pr	
	Flow around particles - Solids Process Engineering Coupling of page and both transfer. The result Process Engineering	
	Coupling of momentum and heat transfer - Thermal Process Engineering Plantage Pinanage Foreign (1997) Plantage Pinanage Pinanage Foreign (1997) Plantage Pinanage	
	Rheology - Bioprocess Engineering	
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering	
	Flow threw porous structures - heterogeneous catalysis	
	Pumps and turbines - Energy- and Environmental Process Engineering	
	Wind- and Wave-Turbines - Renewable Energy	
	Introduction into Computational Fluid Dynamics	
Literature		
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.	
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.	
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.	
	 Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelber 2006. 	
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.	
	 Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunge Springer Verlag, Berlin, Heidelberg, New York, 2006. 	
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW	
	Fachverlage GmbH, Wiesbaden, 2008.	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne	
	GWV Fachverlage GmbH, Wiesbaden, 2009.	
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.	
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring	
	Verlag, Berlin, Heidelberg, 2008.	
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.	

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

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

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

Module M0746: Micro	system Engineering			
Courses				
Title Microsystem Engineering (L0680)		Typ Lecture	Hrs/wk	CP 4 2
Microsystem Engineering (L0682)	Duf Musfulkum	Project-/problem-based Learning	2	2
-	Prof. Manfred Kasper			
	None			
	Basic courses in physics, mathematics and electric engineering			
Knowledge	After taking part suggestibly students have reached the following	na loorning rocults		
-	After taking part successfully, students have reached the following	ng learning results		
Professional Competence Knowledge	The students know about the most important technologies and actuators.	d materials of MEMS as well as	their applicatio	ns in sensors and
Skills	Students are able to analyze and describe the functional be microsystems.	haviour of MEMS components a	and to evaluate	e the potential of
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group	and to present the results accord	ingly.	
Autonomy	Students are able to acquire particular knowledge using special other fields.	ized literature and to integrate a	and associate th	is knowledge with
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description No 10 % Presentation			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the	Electrical Engineering: Core Qualification: Compulsory			
Following Curricula	Computational Science and Engineering: Specialisation Systems	Engineering and Robotics: Elective	ve Compulsory	
	International Management and Engineering: Specialisation II. Ele	-	pulsory	
	International Management and Engineering: Specialisation II. Me			
	International Management and Engineering: Specialisation II. Ele		pulsory	
	International Management and Engineering: Specialisation II. Me Mechanical Engineering and Management: Specialisation Mechal			
	Mechanical Engineering and Management: Specialisation Mechan			
	Mechatronics: Specialisation System Design: Elective Compulsor			
	Mechatronics: Specialisation System Design: Elective Compulsor			
	Biomedical Engineering: Specialisation Artificial Organs and Rego	enerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosth	eses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and 0	Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management and Busines	·	ulsory	
	Microelectronics and Microsystems: Core Qualification: Elective (
	Theoretical Mechanical Engineering: Technical Complementary C	' '		
	Theoretical Mechanical Engineering: Specialisation Bio- and Med			
	Theoretical Mechanical Engineering: Specialisation Bio- and Med	icai Technology: Elective Compul	sory	

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

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	3 3			
-	After taking part successfully, students have reached the	ne following learning results		
Professional Competence				
•	Students are able to denote terms and concepts of Vibi	·	her.	
Skills	Students are able to denote methods of Vibration Theo	ry and develop them further.		
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tas	ks in Vibration Theory.		
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	i		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulso	ry		
Following Curricula	International Management and Engineering: Specialisat	ion II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	on Mechatronics: Elective Compulsor	У	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs	-	e Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	•		
	Biomedical Engineering: Specialisation Management ar		Compulsory	
	Product Development, Materials and Production: Core (• •		
	Naval Architecture and Ocean Engineering: Core Qualification			
	Theoretical Mechanical Engineering: Core Qualification:		V	
	Theoretical Mechanical Engineering: Technical Compler	nentary Course: Elective Compulsor	у	

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 g 2	4 2
Microsystems Technology (L0725)	Draf Has Khiam Triau			Project-/problem-based Learnin	g 2	2
Module Responsible	Prof. Hoc Khiem Trieu None					
Admission Requirements Recommended Previous		stry mechanics and se	emiconductor techn	ology		
Knowledge	busies in physics, enemi.	stry, meenames and st	ermeoridaeeor teerm	iology		
Educational Objectives	After taking part success	sfully, students have re	eached the following	g learning results		
Professional Competence						
Knowledge	Students are able					
	to present and to	explain current fabric	ration techniques fo	or microstructures and espe	cially methods f	or the fabrication (
	*			of in more complex systems	ciany memods .	or are raprication t
			- -			
	• to explain in details	operation principles o	r microsensors and	microactuators and		
	to discuss the poten	tial and limitation of n	nicrosystems in app	lication.		
Skills	Students are capable					
Skins						
	to analyze the feasile	oility of microsystems,	,			
	to develop process f	lows for the fabricatio	n of microstructure	s and		
	to apply them.					
Personal Competence Social Competence	Students are able to pre of audience.	pare and perform thei	ir lab experiments i	n team work as well as to pr	esent and discus	ss the results in fror
Autonomy	None					
Workload in Hours	Independent Study Time	124. Study Time in Le	ecture 56			
Credit points	6	,				
Course achievement		orm	Description			
		ubject theoretical ractical work		führen in Kleingruppen ein d diskutiert die Theorie sowi mten Kurs.		
Examination	Oral exam					
Examination duration and	30 min					
scale						
Assignment for the			-	stems Technology: Elective	Compulsory	
Following Curricula	Electrical Engineering: S					
				Engineering and Robotics: Ele		ТУ
	_			hatronics: Elective Compulson nerative Medicine: Elective C	•	
				ses: Elective Compulsory	5pui30i y	
				ontrol Theory: Elective Comp	ulsory	
	Biomedical Engineering:	Specialisation Manage	ement and Business	s Administration: Elective Co	mpulsory	
	Microelectronics and Mic	rosystems: Core Quali	ification: Elective Co	ompulsory		

Course L0724: Microsystems	Technology
Тур	
СР	4
Workload in Hours	
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	Introduction (historical view, scientific and economic relevance, scaling laws)
	 Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; 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, SUB, rapid prototyping) Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pi 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; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: splinstor and thermal conductivity sensor; metal oxide semiconductor gas sensor, capanic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators, Microflu
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

Module M0814: Techn	pology Management
	Hanagement
Courses	
Title	Typ Hrs/wk CP
Technology Management (L0849) Technology Management Seminar (Project-/problem-based Learning 3 3 (L0850) Project-/problem-based Learning 2 3
	Prof. Cornelius Herstatt
Admission Requirements	
Knowledge	Bachelor knowledge in business management
	After taking part successfully, students have reached the following learning results
	After taking part successfully, students have reached the following learning results
Professional Competence	Students will gain doon incights into
Knowledge	Students will gain deep insights into:
	International R&D-Management
	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	The course aims to:
	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, operatio
	organizational and process-related aspects)
	Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and
	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 iss
	concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include:
	Defended to the second of the
	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 team
	Raise awareness for globabl issues
Autonomy	
	Gain access to knowledge sources
	Discuss recent research debates in the context of Technology and Innovation Management
	Develop presentation skills
	Discussion of international cases in R&D-Management
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	
Course achievement	
Examination	
Examination Examination duration and	
examination duration and scale	20 minutes
	Clobal Innovation Managements Core Qualifications Computers
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 Riomedical Engineering: Specialisation Management and Rusiness Administration: Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Compulsory

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

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

Module M0846: Contr	ol Systems Theory and Design				
Courses					
Title		Тур	Hrs/wk	СР	
Control Systems Theory and Design		Lecture	2	4	
Control Systems Theory and Design	n (L0657)	Recitation Section (small)	2	2	
Module Responsible	Prof. Herbert Werner				
Admission Requirements	None				
	Introduction to Control Systems				
Knowledge					
Educational Objectives	After taking part successfully, students have reache	d the following learning results			
Professional Competence					
Knowledge	 Students can explain how linear dynamic sy 	stems are represented as state space m	odels; they can	interpret the syster	
	response to initial states or external excitatio	n as trajectories in state space			
	They can explain the system properties cont	rollability and observability, and their rel	ationship to state	e feedback and stat	
	estimation, respectively	l realization			
	They can explain the significance of a minima They can explain observer-based state feedb		cking and disturk	ance rejection	
	They can extend all of the above to multi-inpl		cking and disturt	rance rejection	
	They can explain the z-transform and its relationships				
	They can explain state space models and training	nsfer function models of discrete-time sys	tems		
	They can explain the experimental identificat	ion of ARX models of dynamic systems, a	nd how the ident	ification problem ca	
	be solved by solving a normal equation				
	They can explain how a state space model ca	n be constructed from a discrete-time im	oulse response		
Skills	Students can transform transfor function mass	dels into state space models and vice vers			
	 Students can transform transfer function mod They can assess controllability and observability 		a		
	They can design LQG controllers for multivari				
	They can carry out a controller design both	•	nain, and decide	which is appropriat	
	for a given sampling rate				
	They can identify transfer function models an	d state space models of dynamic systems	from experimen	ital data	
	They can carry out all these tasks using sta	andard software tools (Matlab Control To	olbox, System Id	entification Toolbox	
	Simulink)				
Personal Competence					
Social Competence	Students can work in small groups on specific proble	ems to arrive at joint solutions.			
Autonomy	Students can obtain information from provided so	urces (lecture notes, software document	ation, experimer	nt guides) and use	
	when solving given problems.				
	They can assess their knowledge in weekly on-line t	ests and thereby control their learning pr	naress		
	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		. 50			
Course achievement	None				
Examination					
Examination duration and					
scale	120 11111				
Assignment for the	Computer Science: Specialisation Intelligence Engin	eering: Elective Compulsory			
Following Curricula					
-	Energy Systems: Core Qualification: Elective Compu	lsory			
	Aircraft Systems Engineering: Specialisation Aircraft				
	Aircraft Systems Engineering: Specialisation Avionic				
	Computational Science and Engineering: Specialisat		-		
	International Management and Engineering: Special	• •			
	International Management and Engineering: Special Mechanical Engineering and Management: Specialis		Ji ý		
	Mechatronics: Core Qualification: Compulsory	and Precinationics. License Compuisory			
	Biomedical Engineering: Specialisation Artificial Org.	ans and Regenerative Medicine: Elective (Compulsory		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory				
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
	Product Development, Materials and Production: Col	•			
	Theoretical Mechanical Engineering: Core Qualification	ion: Compulsory			

Typ	Lecture			
Hrs/wk				
CP				
	Independent Study Time 92, Study Time in Lecture 28			
	Prof. Herbert Werner			
Language				
Cycle				
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			
	oles 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	Warran II. Lashina Natas Castral Cintana Thanna and D. Cart			
	Werner, H., Lecture Notes "Control Systems Theory and Design" The Market Williams Control Propries Used 1999.			
	T. Kailath "Linear Systems", Prentice Hall, 1980 K. Antaran B. Witharan and "Granutan Controlled Systems" Prentice Hall, 1997.			
	K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997			
	L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999			

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

odule M0867: Produ	ction Planning & Control a	nd Digital Enterprise			
ourses					
itle		Тур	Hrs/wk	СР	
ne Digital Enterprise (L0932)		Lecture	2	2	
roduction Planning and Control (L	0929)	Lecture	2	2	
roduction Planning and Control (L	0930)	Recitation Section (small)	1	1	
xercise: The Digital Enterprise (L0	933)	Recitation Section (small)	1	1	
Module Responsible	Prof. Hermann Lödding				
Admission Requirements	None				
Recommended Previous	Fundamentals of Production and Quality	y Management			
Knowledge					
Educational Objectives	After taking part successfully, students	have reached the following learning results			
Professional Competence	•	•			
Knowledge	Students can explain the contents of th	ne module in detail and take a critical position to them	1.		
-	·	applying models and methods from the module to indi			
Personal Competence					
•	Students can develop joint solutions in mixed teams and present them to others.				
Autonomy					
	Independent Study Time 96, Study Time in Lecture 84				
Credit points					
Course achievement					
Examination	Written exam				
Examination duration and					
scale					
Assignment for the	International Management and Enginee	ering: Specialisation II. Product Development and Prod	luction: Elective Co	ompulsorv	
•	3	pecialisation Production and Logistics: Elective Comp		,	
3 ·· · · ·	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory				
		Implants and Endoprostheses: Elective Compulsory	, , ,		
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory				
		Management and Business Administration: Compulso			
	Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory				
	•	oduction: Specialisation Production: Compulsory			
	·	roduction: Specialisation Materials: Elective Compulsor	ry		
	·	pecialisation Product Development and Production: Ele	•		
		echnical Complementary Course: Elective Compulsory			

Course L0932: The Digital Er	
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 Pl	ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

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

Module M0921: Electi	ronic Circuits fo	r Medical Applic	ations			
Courses						
Title Electronic Circuits for Medical Appli Electronic Circuits for Medical Appli				Typ Lecture Recitation Section (small)	Hrs/wk 2 1	CP 3 2
Electronic Circuits for Medical Appli				Practical Course	1	1
Module Responsible	Prof. Matthias Kuhl					
Admission Requirements	None					
Recommended Previous	Fundamentals of elec	trical engineering				
Knowledge						
Educational Objectives	After taking part succ	essfully, students have r	eached the followi	ng learning results		
Professional Competence						
Knowledge Skills	Students can e Students are al Students can e Students can d Students can d Students can e	ole to explain the build-uxemplify the communica escribe the special featu xplain the functions of proble to discuss the potent	p of an action pote tion between neur res of low-noise ar rostheses, e. g. an ial and limitations	of cochlea implants and art	long an axon	
	 Students can calculate the time dependent voltage behavior of an action potential Students can give scenarios for further improvement of low-noise and low-power signal acquisition. Students can develop the block diagrams of prosthetic systems Students can define the building blocks of electronic systems for an articifial eye. 					
Personal Competence Social Competence						
Autonomy	 Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. Students can break down their work in appropriate work packages and schedule their work in a realistic way. Students can handle the complex data structures of bioelectrical experiments without needing support. Students are able to act in a responsible manner in all cases and situations of experimental work. 					
Workload in Hours	Independent Study Ti	me 124, Study Time in L	ecture 56			
Credit points						
Course achievement	Yes None No None	Subject theoretical practical work Excercises	Description and			
Examination	Written exam					
Examination duration and						
scale	+	. Canadalli . Cana	Tarkardo = =1 - 11	Camanula i		
Assignment for the Following Curricula		: Specialisation Medical ⁻ : Specialisation Medical ⁻				
i onowing curricula	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory					
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory					
	_	• .		Control Theory: Compulsory	/	
	Biomedical Engineering	ng: Specialisation Manag	ement and Busine	ss Administration: Elective	Compulsory	
	Microelectronics and I	Microsystems: Specialisa	tion Microelectron	ics Complements: Elective	Compulsory	
	Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory					
				Course: Elective Compulsor		
	i neoretical Mechanica	aı Engineering: Specialisa	ation Bio- and Med	ical Technology: Elective C	ompuisory	

Course L0696: Electronic Circ	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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 Circ	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g.,	in the module Mechanics II (forces and	I moments, stres	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain el	nergy).		
Educational Objectives	After taking part successfully, students have reached t	he following learning 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 Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Co	mpulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation	on Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Elect	ve Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Er	ndoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management ar	nd Business Administration: Elective Co	mpulsory	
	Product Development, Materials and Production: Core			
	Theoretical Mechanical Engineering: Technical Comple			
	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: Continuum Mechanics Exercise		
Тур	Recitation Section (small)	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Christian Cyron	
Language	DE	
Cycle	WiSe	
Content	 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: Mater	rial Modeling			
Courses				
Title		Тур	Hrs/wk	СР
Material Modeling (L1535)		Lecture	2	3
Material Modeling (L1536)		Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear and nonlinear continuum mechanics as taught,	e.g., in the modules Mechanic	s II and Continuu	m Mechanics (forces
Knowledge	and moments, stress, linear and nonlinear strain, free-body prir	ciple, linear and nonlinear cor	nstitutive laws, st	rain energy)
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge	The students can explain the fundamentals of multidimensional	consitutive material laws		
Skills	The students can implement their own material laws in finite e	ement codes. In particular, th	e students can a	oply their knowledge
	to various problems of material science and evaluate the corresponding material models.			
Personal Competence				
Social Competence	The students are able to develop solutions, to present them to	specialists and to develop idea	s 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 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Computational Science and Engineering: Specialisation Scientifi	c Computing: Elective Compu	sory	
Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory	,		
	Mechanical Engineering and Management: Specialisation Mater	ials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Rec		Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosti			
	Biomedical Engineering: Specialisation Medical Technology and	•	•	
	Biomedical Engineering: Specialisation Management and Busine		ompulsory	
	Product Development, Materials and Production: Core Qualification			
	Theoretical Mechanical Engineering: Specialisation Materials Sc	lence: Elective Compulsory		

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

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

Module M1199: Advar	nced Functional Materials	
Courses		
Title	Typ Hrs/wk CP	
Advanced Functional Materials (L16	L625) Seminar 2 6	
Module Responsible	Prof. Patrick Huber	
Admission Requirements	None	
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in	particular
	metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.	
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to d	esign new
	materials considering architectural principles from the micro- to the macroscale. The students will also gain an ov	
	modern materials science, which enables them to select optimum materials combinations depending on the	technical
	applications.	
Personal Competence		
· ·	The students are able to present solutions to specialists and to develop ideas further.	
Social competence	The stauchts are able to present solutions to specialists and to develop facus farther.	
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		
Examination		
Examination duration and		
scale		
Assignment for the	Materials Science: Core Qualification: Compulsory	
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	

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

Module M1241: Select	ed Topics of Biomedical Engineering	J - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L16	63)	Seminar	2	3
Introduction to Waveguides, Antenn	as, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antenn	as, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appro	val of Implants (L1588)	Lecture	2	3
Experimental Methods for the Chara	cterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanics	(L1583)	Seminar	2	3
Seminar Biomedical Engineering (L1	.890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points				
Assignment for the	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory			
Following Curricula	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory			
_	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
l l	3 ,	3,		

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

Тур	Lecture				
Hrs/wk	3				
СР					
Workload in Hours	dependent Study Time 78, Study Time in Lecture 42				
Examination Form	lündliche Prüfung				
Examination duration and	0 min				
scale					
Lecturer	Prof. Christian Schuster				
Language	DE/EN				
Cycle	SoSe				
	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well of Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequen high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Steady-state sinusoidal description of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques				
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)				
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)				
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)				
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)				
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)				
	- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)				

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility				
Тур	ecitation Section (small)			
Hrs/wk				
СР				
Workload in Hours	ndependent Study Time 32, Study Time in Lecture 28			
Examination Form	ündliche Prüfung			
Examination duration and	0 min			
scale				
Lecturer	Prof. Christian Schuster			
Language	DE/EN			
Cycle	SoSe			
Content	See interlocking course			
Literature	See interlocking course			

Course L1588: Development and Regulatory Approval of Implants					
Тур	ecture				
Hrs/wk	2				
СР	3				
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28				
Examination Form	lausur				
Examination duration and	90 Minuten				
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	ecture			
Hrs/wk	2			
СР	3			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Examination Form	Klausur			
Examination duration and	90 min			
scale				
Lecturer	Prof. Patrick Huber			
Language	DE			
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).			

Тур	5eminar				
Hrs/wk					
СР	3				
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28				
Examination Form	Klausur				
xamination duration and	90 Minuten				
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	eminar		
Hrs/wk			
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Examination Form	Referat		
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

Course L1130: Six Sigma			
Тур	Lecture		
Hrs/wk			
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and	90 Minuten		
scale			
Lecturer	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		

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

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

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

Course L0379: Ceramics 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	90 Minuten				
scale					
	Dr. Rolf Janßen				
Language					
Cycle					
Content	Introduction to ceramic processing with emphasis on advanced structural ceramics. The course focus predominatly on powder-based processing, e.g. "powder-metauurgical techniques and sintering (soild state and liquid phase). Also, some aspects of glass and cement science as well as new developments in powderless forming techniques of ceramics and ceramic composites will be addressed Examples will be discussed in order to give engineering students an understanding of technology development and specific applications of ceramic components.				
	Content:	1. Introduction			
	Inhalt:	2. Raw materials			
		3. Powder fabrication			
		4. Powder processing			
		5. Shape-forming processes			
	6. Densification, sintering				
	7. Glass and Cement technology				
		8. Ceramic-metal joining techniques			
Literature	W.D. Kingery, "Introduction to 0	Ceramics", John Wiley & Sons, New York, 1975			
	ASM Engineering Materials Han	dbook Vol.4 "Ceramics and Glasses", 1991			
	D.W. Richerson, "Modern Ceramic Engineering", Marcel Decker, New York, 1992				
	Skript zur Vorlesung				

Module M1279: MED I	II: Introduction to Biochemistry and Molecular Biology		
Courses			
Title	Typ Hrs/	wk (CP CP
Introduction to Biochemistry and M	••	3	1
Module Responsible	Prof. Hans-Jürgen Kreienkamp		
Admission Requirements	None		
Recommended Previous	None		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can		
	describe basic biomolecules;		
	explain how genetic information is coded in the DNA;		
	explain the connection between DNA and proteins;		
CL III.	The defeated as		
SKIIIS	s 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			
•	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 thems	elves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	t None		
Examination	Written exam		
Examination duration and	60 minutes		
scale			
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Co	ompulsory	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineer	ering, Focus	Biomechanics:
	Compulsory		
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineer	ring, Focus	Biomechanics:
	Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Co	mpuisory	
	Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory		
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsor	v	
	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				
	Lecture			
Hrs/wk				
СР				
	Independent Study Time 62, Study Time in Lecture 28			
Lecturer	Prof. Hans-Jürgen Kreienkamp			
Language	DE			
Cycle	WiSe			
Content				
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage			
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008			

Module M1333: BIO I:	Implants and Fracture Healing			
Courses				
Title Implants and Fracture Healing (L03	Typ Hrs/wk CP 376) Lecture 2 3			
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous Knowledge	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
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 determine the forces acting within the human body under quasi-static situations under specific assumptions.			
Personal Competence Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.			
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics:			
Following Curricula	Compulsory			
	General Engineering Science (German program, 7 semester): 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 Artificial Organs and Regenerative Medicine: Elective Compulsory			
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory			
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory			
	Orientierungsstudium: Core Qualification: Elective Compulsory			
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

Module M1334: BIO II	: Biomaterials				
Courses					
Title		Тур	Hrs/wk	СР	
Biomaterials (L0593)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	Basic knowledge of orthopedic and surgical technique	s is recommended.			
Knowledge					
Educational Objectives	After taking part successfully, students have reached	the following learning results			
Professional Competence					
Knowledge	The students can describe the materials of the human	body and the materials being us	sed in medical engineerir	ng, and their fields of	
	use.				
Skills	The students can explain the advantages and disadvantages of different kinds of biomaterials.				
SKIIIS	The students can explain the advantages and disadva	nitages of different kinds of bloth	lateriais.		
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 info	ormation with respect to	its credibility.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	ļ			
Credit points	3				
Course achievement	None				
Examination	Written exam				
Examination duration and	90 min				
scale					
Assignment for the	International Management and Engineering: Specialis	ation II. Process Engineering and	Biotechnology: Elective (Compulsory	
Following Curricula	Materials Science: Specialisation Nano and Hybrid Ma	terials: Elective Compulsory			
	Biomedical Engineering: Specialisation Artificial Organ	is and Regenerative Medicine: El	ective Compulsory		
	Biomedical Engineering: Specialisation Implants and E				
	Biomedical Engineering: Specialisation Medical Techn	••			
	Biomedical Engineering: Specialisation Management a				
	Theoretical Mechanical Engineering: Technical Comple		•		
	Theoretical Mechanical Engineering: Specialisation Bio	o- and Medical Technology: Electi	ive Compulsory		

Course L0593: Biomaterials				
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	WiSe Topics to be covered include:			
	Introduction (Importance, nomenclature, relations)			
	Biological materials			
	2.1 Basics (components, testing methods)			
	2.2 Bone (composition, development, properties, influencing factors)			
	2.3 Cartilage (composition, development, structure, properties, influencing factors)			
	2.4 Fluids (blood, synovial fluid)			
	3 Biological structures			
	3.1 Menisci of the knee joint			
	3.2 Intervertebral discs			
	3.3 Teeth			
	3.4 Ligaments			
	3.5 Tendons			
	3.6 Skin			
	3.7 Nervs			
	3.8 Muscles			
	4. Replacement materials			
	4.1 Basics (history, requirements, norms)			
	4.2 Steel (alloys, properties, reaction of the body)			
	4.3 Titan (alloys, properties, reaction of the body)			
	4.4 Ceramics and glas (properties, reaction of the body)			
	4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)			
	4.6 Natural replacement materials			
	Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics.			
Literature	Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.			
	Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987. Hastings C.: Machanical proporties of biomaterials, proceedings hold at Koole University, Soptember 1079, New York, Wiley, 1999.			
	Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.			
	Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988. Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.			
	Wintermantel, E. und Ha, SW : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996.			

Courses				
Title	Typ Hrs/wk CP			
Finite Element Methods (L0291)	Lecture 2 3 Recitation Section (large) 2 3			
Finite Element Methods (L0804)				
Module Responsible				
Admission Requirements	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)			
	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence				
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give overview of the theoretical and methodical basis of the method.			
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.			
Personal Competence Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.			
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element routin Problems can be identified and the results are critically scrutinized.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement				
	No 20 % Midterm			
Examination				
Examination duration and				
scale				
_	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory			
ronowing curricula	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory			
	Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory			
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory			
	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory			
	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory			
	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory			
	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory			
	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: 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			
	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			
	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			
	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			
	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			

Course L0291: Finite Elemen	Course L0291: Finite Element Methods			
Тур	Lecture			
Hrs/wk	2			
СР	3			
Workload in Hours	ndependent 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			

ourse L0804: Finite Element Methods				
Тур	ecitation Section (large)			
Hrs/wk				
СР				
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28			
Lecturer	rof. Otto von Estorff			
Language	N			
Cycle	WiSe			
Content	See interlocking course			
Literature	See interlocking course			

Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polymers (L0389)		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous Knowledge	Basics: chemistry / physics / material scier	nce		
Educational Objectives	After taking part successfully, students ha	vo reached the following learning results		
Professional Competence	After taking part successionly, students na	ve reactied the following learning results		
Knowledge	Students can use the knowledge of plastic	s and define the necessary testing and analy	vsis	
raremeage			, 5.5.	
	They can explain the complex relationship	s structure-property relationship and		
	the interactions of chemical structure of th	ne polymers, including to explain neighboring	g contexts (e.g. sustaina	bility, environmenta
	protection).			
Chille	Students are capable of			
SKIIIS	Students are capable of			
	- using standardized calculation method	s in a given context to mechanical prope	erties (modulus, streng	th) to calculate an
	evaluate the different materials.			
	- selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.			
	3	, , ,		
Personal Competence				
Social Competence	Social Competence Students can			
	- arrive at funded work results in heteroge	nius groups and document them.		
	- provide appropriate feedback and handle feedback on their own performance constructively.			
Autonomy	Students are able to			
,				
	- assess their own strengths and weaknesses.			
	- assess their own state of learning in spec	ific terms and to define further work steps o	n this basis.	
	- assess possible consequences of their pr	oressional activity.		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	,			
Following Curricula	Biomedical Engineering: Specialisation Imp			
		ificial Organs and Regenerative Medicine: Ele		
		nagement and Business Administration: Elec dical Technology and Control Theory: Electiv		
		dical Technology and Control Theory: Elective Iction: Specialisation Production: Elective Co		
	· ·	action: Specialisation Materials: Elective Com		
	'	uction: Specialisation Product Development:		
	· ·	nical Complementary Course: Elective Comp		
	Theoretical Mechanical Engineering: Speci	alisation Materials Science: Elective Compuls	sory	

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

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

Courses					
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347) Lecture Tissue Engineering - Reger	nerative Medicine (I 166	1)	Seminar Seminar	2 2	3
Module Responsible		.,			
Admission Requirements					
Recommended Previous					
Knowledge	None				
Educational Objectives	After taking part suc	cessfully, students have re	ached the following learning results		
Professional Competence	7 incor carring part suc	essiany, stadents nave re	action the following learning results		
	After successful completion of the module students will be able to describe the basic methods of regenerative medicine explain the use of the tissue cells for different methods of tissue engineering. They are able to give a basic overview of meth the cultivation of animal and human cells.				
		utline the actual concep of the discussed topics.	ts of Tissue Engineering and regenera	ative medicine and ca	n explain the bas
Skills	After successful com	pletion of the module stud	ents are		
	 able to use medical databases for acquirierung and presentation of relevant up-to-date data independently able to present their work results in the form of presentations able to carry out basic cell culture methods and the corresponding analysis independently able to analyse and evaluate current research topics for Tissue Engineering and regenerative medicine. 				
Personal Competence Social Competence	defend them.		with 2-4 students to solve given tasks ar		in the plenary and t
Autonomy	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 perso independently including a presentation of the results.				
Workload in Hours	Independent Study 1	ime 124, Study Time in Le	cture 56		
Credit points		· · · · · · · · · · · · · · · · · · ·			
Course achievement	Compulsory Bonus	Form	Description		
	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pro	otocol for lecture series	
Examination	Presentation				
Examination duration and	Oral presentation +	discussion (30 min)			
scale					
Assignment for the	Biomedical Engineer	ng: Specialisation Implant	s and Endoprostheses: Elective Compuls	ory	
Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory				
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
	Biomedical Engineer	ng: Specialisation Medical	Technology and Control Theory: Elective	e Compulsory	

Course L0347: Regenerative	Medicine
Тур	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Dr. Frank Feyerabend
Language	DE/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 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			

	ectromagnetics: Principles an	a Applications		
Courses				
Title		Тур	Hrs/wk	СР
Bioelectromagnetics: Principles and	• •	Lecture	3	5
Bioelectromagnetics: Principles and		Recitation Section (small)	2	1
	Prof. Christian Schuster			
Admission Requirements				
Recommended Previous	Basic principles of physics			
Knowledge				
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence	3,000	3 3		
Knowledge	of electromagnetic fields in biological tiss them corresponding to wavelength and f	relationships, and methods of bioelectromagnetics ue. They can define and exemplify the most imprequency of the fields. They can give an overvimagnetic fields in practical applications. They celds in medical technology.	oortant physical pl ew over measure	henomena and ord ment and numeric
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.			
Personal Competence Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).			
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English.			
Workload in Hours	Independent Study Time 110, Study Time	in Lecture 70		
Credit points				
Course achievement	Compulsory Bonus Form	Description		
	Yes 10 % Presentation			
Examination	Oral exam			
Examination duration and	45 min			
scale				
Assignment for the	Electrical Engineering: Specialisation Media	cal Technology: Elective Compulsory		
Following Curricula		pwave Engineering, Optics, and Electromagnetic C	ompatibility: Elect	ive Compulsory
•		g: Specialisation II. Electrical Engineering: Elective		
		ificial Organs and Regenerative Medicine: Elective	. ,	
	- · ·	plants and Endoprostheses: Elective Compulsory	. ,	
		dical Technology and Control Theory: Elective Con	npulsory	
	Biomedical Engineering: Specialisation Ma	nagement and Business Administration: Elective C	compulsory	
	Theoretical Mechanical Engineering: Techr	nical Complementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Specia	alisation Bio- and Medical Technology: Elective Co	mpulsory	

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

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

Module M1384: Case	Studies for Regenerative Medi	cine and Tissue Engineering	9	
Courses				
Title		Тур	Hrs/wk	СР
Case Studies for Regenerative Med	licine and Tissue Engineering (L1963)	Seminar	3	6
Module Responsible	Prof. Ralf Pörtner			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 138, Study Time in	Lecture 42		
Credit points	6			
Course achievement	None			
Examination	Presentation			
Examination duration and	45 min			
scale				
Assignment for the	Biomedical Engineering: Specialisation Artific	ial Organs and Regenerative Medicine: C	Compulsory	<u> </u>
Following Curricula				

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

Module M0630: Robot	tics and Naviga	tion in Medicine				
Courses						
Title Robotics and Navigation in Medicine (L0335) Robotics and Navigation in Medicine (L0338)				Typ Lecture Project Seminar	Hrs/wk 2 2	CP 3 2
Robotics and Navigation in Medicin						1
Module Responsible		efer				
Admission Requirements	None					
Recommended Previous Knowledge	 principles of math (algebra, analysis/calculus) principles of programming, e.g., in Java or C++ solid R or Matlab skills 					
Educational Objectives	After taking part succ	essfully, students have	reached the followi	ng learning results		
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations. The students are able to design and evaluate navigation systems and robotic systems for medical applications.					
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Study Ti	me 110, Study Time in	Lecture 70			
Credit points	6					
Course achievement	Compulsory Bonus Yes 10 % Yes 10 %	Form Presentation Written elaboration	Description			
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the Following Curricula	Electrical Engineering International Manage Mechatronics: Special Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin Biomedical Engineerin Product Development Product Development	isation Intelligent Systeng: Specialisation Artific ng: Specialisation Impla ng: Specialisation Medic ng: Specialisation Mana ng: Specialisation Mana ng: Materials and Product ng: Materials and Product	Technology: Electi Specialisation II. Ele ims and Robotics: E ial Organs and Reg nts and Endoprosth ial Technology and gement and Busine ion: Specialisation I	ve Compulsory ectrical Engineering: Elective elective Compulsory enerative Medicine: Elective esess: Elective Compulsory Control Theory: Elective Cor ss Administration: Elective Cor product Development: Elective Production: Elective Compuls	Compulsory npulsory compulsory ve Compulsory sory	
	Theoretical Mechanic	al Engineering: Technic	al Complementary	Materials: Elective Compulso Course: Elective Compulsory lical Technology: Elective Co		

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	ourse 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: Introd	duction into Me	dical Technology an	d Systems			
Courses						
Title			Туј	2	Hrs/wk	СР
Introduction into Medical Technology and Systems (L0342)				ture	2	3
Introduction into Medical Technolog	gy and Systems (L0343)		Proj	ject Seminar	2	2
Introduction into Medical Technolog	gy and Systems (L1876)		Rec	itation Section (large)	1	1
Module Responsible	Prof. Alexander Schlae	efer				
Admission Requirements	None					
Recommended Previous	principles of math (alg	jebra, analysis/calculus)				
Knowledge	principles of stochast	ics				
	principles of programi	ning, R/Matlab				
Educational Objectives	After taking part succ	essfully, students have reach	ed the following le	earning results		
Professional Competence						
Knowledge	The students can ex	plain principles of medical t	echnology, includ	ing imaging systems,	computer aided s	urgery, and medical
	information systems.	They are able to give an over	view of regulatory	affairs and standards	in medical technolo	ogy.
Skills	The students are able	to evaluate systems and me	dical devices in th	e context of clinical an	nlications	
Skills	The students are able	to evaluate systems and me	arear acvices in the	e context of clinical ap	prications.	
Personal Competence						
Social Competence	The students describe	a problem in medical techno	ology as a project,	and define tasks that a	are solved in a joint	effort.
Autonomy	The students can refle	ect their knowledge and doc	ument the results	of their work. They ca	an present the resu	Its in an appropriate
	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		me 110, Study Time in Lectur	e 70			
Credit points						
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 % Yes 10 %	Written elaboration Presentation				
Examination	Written exam	riesentation				
Examination duration and	90 minutes					
scale	50 minutes					
Assignment for the	General Engineering S	cience (German program, 7	semester): Special	isation Biomedical End	gineering: Compulso	orv
Following Curricula		ecialisation Computer and So		_		•
		Core Qualification: Elective		, ,		
	General Engineering S	cience (English program, 7 s	emester): Speciali	sation Biomedical Engi	ineering: Compulsoi	ry
	Computational Science	e and Engineering: Specialisa	ition II. Mathemati	cs & Engineering Scien	nce: Elective Compu	ilsory
	Computational Science	e and Engineering: Specialisa	ition Computer Sci	ience: Elective Compul	sory	
	Computational Scienc	e and Engineering: Specialisa	tion Engineering S	Sciences: Elective Com	pulsory	
	Biomedical Engineering	g: Specialisation Artificial Or	gans and Regener	ative Medicine: Elective	e Compulsory	
	Biomedical Engineering	g: Specialisation Implants an	d Endoprostheses	: Elective Compulsory		
	Biomedical Engineering	g: Specialisation Medical Tec	hnology and Cont	rol Theory: Elective Co	mpulsory	
	_	g: Specialisation Managemer			Compulsory	
	Technomathematics:	Specialisation III. Engineering	Science: Elective	Compulsory		

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	CalculusLinear AlgebraEngineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the	following learning results		
Professional Competence		<u> </u>		
	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
	Students are able to apply existing methods and procesur	es of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence	Students can reach working regults also in groups			
· ·	Students can reach working results also in groups.	hually and to identify and follow	un novel recearch ta	sks by thomsolves
-	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				
Examination				
Examination duration and				
scale	2 110013			
	Aircraft Systems Engineering: Specialisation Aircraft Syste	ms: Elective Compulsory		
•			oulsory	
	Mechanical Engineering and Management: Specialisation I		•	
	Mechatronics: Specialisation System Design: Elective Com	pulsory		
	Mechatronics: Specialisation Intelligent Systems and Robo	tics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs an	d Regenerative Medicine: Electi	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and Endo	prostheses: Elective Compulsory	1	
	Biomedical Engineering: Specialisation Medical Technology	•		
	Biomedical Engineering: Specialisation Management and E		Compulsory	
	Product Development, Materials and Production: Core Qua			
	Theoretical Mechanical Engineering: Technical Complement		ry	
	Theoretical Mechanical Engineering: Core Qualification: Ele	ective 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					
itle		Typ	Hrs/wk	СР	
emiconductor Technology (L0722)		Typ Lecture	4	4	
emiconductor Technology (L0723)		Practical Course	2	2	
Module Responsible	Prof. Hoc Khiem Trieu				
-	None				
	Basics in physics, chemistry, material scie	ace and semiconductor devices			
Knowledge	basics in physics, chemistry, material scien	ice and semiconductor devices			
_	After taking part successfully, students ha	reached the following learning results			
Professional Competence	titel taking part saccessiany, stadents na	ve reaction the following learning results			
Knowledge					
Knowledge					
9	Students are able				
	to describe and to explain current fabr	ication techniques for Si and GaAs substrates			
	to describe and to explain earrent labi	reaction recriminates for 51 and Gaza substrates	',		
	to discuss in details the relevant	fabrication processes, process flows and	the impact thereof o	n the fabrication	
2	semiconductor devices and integrated circ	uits and			
	to present integrated process flows.				
	to present megrated process nows.				
Skills					
Skills					
9	Students are capable				
	to analyze the impact of process para	meters on the processing results			
	to select and to evaluate processes and				
	to develop process flows for the fabrication of semiconductor devices.				
	to develop process from for the fublication of semiconductor devices.				
Personal Competence					
Social Competence					
Social competence					
9	Students are able to prepare and perform	their lab experiments in team work as well as	s to present and discus	s the results in fro	
	of audience.				
Autonomy 1	None				
Workload in Hours	ndependent Study Time 96, Study Time in	Lecture 84			
Credit points	5				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Accianment for the	Sloctrical Engineering: Specialisation No.	oloctronics and Microsystems Tashnal El-	activo Compulsory		
•		electronics and Microsystems Technology: Ele	, ,		
_		ficial Organs and Regenerative Medicine: Electrical Organs and Endoprostheses: Elective Compulso			
		dical Technology and Control Theory: Elective			
	3 3 1	nagement and Business Administration: Elective	, ,		
	Microelectronics and Microsystems: Specia				

Typ Lecture Hrs/wk 4 CP 4 Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Lecturer Prof. Hoc Khiem Trieu Language DE/EN Cycle SoSe Content • 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 • Wafer fabrication (process flow, specification, SOI) • Fabrication processes	I float zone process)
CP 4 Workload in Hours Independent Study Time 64, Study Time in Lecture 56 Lecturer Prof. Hoc Khiem Trieu Language DE/EN Cycle SoSe Content 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 Wafer fabrication (process flow, specification, SOI) Fabrication processes	I float zone process)
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 Wafer fabrication (process flow, specification, SOI) Fabrication processes	l float zone process)
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 Wafer fabrication (process flow, specification, SOI) Fabrication processes	l float zone process)
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 Wafer fabrication (process flow, specification, SOI) Fabrication processes	I float zone process)
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 Wafer fabrication (process flow, specification, SOI) Fabrication processes	I float zone process)
 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 Wafer fabrication (process flow, specification, SOI) Fabrication processes 	l float zone process)
 Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, or order effects and process technology, ion implantation: theory, implantation profile, channeling, in annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth procestemperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitation, APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques (subtractive methods, photolithography: resist properties, printing techniques) 	mplantation damage reactions, kinetics thermal oxidation of ess, reaction kinetics axy; CVD techniques hniques: high vacuur
and projection printing, resolution limit, practical issues and equipment, additive methods: li electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etc anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasm backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) • Process integration (CMOS process, bipolar process) • Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly wire bonding, TAB and flip chip, wafer level package, 3D stacking)	liftoff technique an t lithography, electro cching: isotropic an na enhanced etching
Literature S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons	
S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons	
U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag	
	, Teubner Verlag
H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen,	
H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin	

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

Module M0835: Huma	noid Robotics				
Courses					
Title		Тур	Hrs/wk	СР	
Humanoid Robotics (L0663)		Seminar	2	2	
Module Responsible	Patrick Göttsch				
Admission Requirements	None				
Recommended Previous					
Knowledge	a Introduction to control systems				
	 Introduction to control systems Control theory and design 				
	onle of theory and design				
Educational Objectives	After taking part successfully, students have	ve reached the following learning results			
Professional Competence					
Knowledge	Students can explain humanoid robo	ots.			
		I concepts for different tasks in humanoid rob	ootics.		
Skills					
SKIIIS	Students acquire knowledge about s	selected aspects of humanoid robotics, based	on specified literature		
	Students generalize developed results and present them to the participants				
	Students practice to prepare and given	ve a presentation			
Personal Competence					
Social Competence					
	 Students are capable of developing solutions in interdisciplinary teams and present them They are able to provide appropriate feedback and handle constructive criticism of their own results 				
	They are able to provide appropriate	e feedback and handle constructive criticism	of their own results		
Autonomy	Charles and a street and a street	danish	: f:f- t!-		
	solution	drawbacks of different forms of presentat	ion for specific tasks	and select the best	
	• Students familiarize themselves with a scientific field, are able of introduce it and follow presentations of other students,				
	such that a scientific discussion dev			,	
Workload in Hours	Independent Study Time 32, Study Time in	Lecture 28			
Credit points Course achievement	None				
Examination	Presentation				
Examination Examination duration and	30 min				
scale	30 11111				
Assignment for the	Mechatronics: Specialisation Intelligent Sys	stems and Robotics: Elective Compulsory			
Following Curricula	Mechatronics: Specialisation System Desig				
		ficial Organs and Regenerative Medicine: Elec	ctive Compulsory		
	Biomedical Engineering: Specialisation Imp	plants and Endoprostheses: Elective Compulso	ory		
	Biomedical Engineering: Specialisation Med	dical Technology and Control Theory: Elective	e Compulsory		
		nagement and Business Administration: Elect			
		ical Complementary Course: Elective Compu	Isory		
	Theoretical Mechanical Engineering: Core (Qualification: Elective Compulsory			

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

Module M0838: Linea	r and Nonlinear System Iden	tifikation		
Courses				
Title Linear and Nonlinear System Identi	fication (L0660)	Typ Lecture	Hrs/wk	CP 3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	 Classical control (frequency response) State space methods Discrete-time systems Linear algebra, singular value decord Basic knowledge about stochastic p 	mposition		
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	nonlinear model structures They can explain how multilayer pe They can explain how an approxima They can explain the idea of subspa Students are capable of applying models for dynamic systems They are capable of implementing a They are capable of applying subsp They can do the above using standa	framework of the prediction error method an acceptron networks are used to model nonlineate predictive control scheme can be based or ace identification and its relation to Kalman rethe predicition error method to the experimental anonlinear predictive control scheme based of ace algorithms to the experimental identification and software tools (including the Matlab System ecific problems to arrive at joint solutions.	ar dynamics In neural network model Identification of line in a neural network model In a neural network model Identification Toolboom	s linear and nonlinear del dynamic systems x)
	-			
Workload in Hours	Independent Study Time 62, Study Time in	n Lecture 28		
Credit points				
Course achievement				
Examination Examination duration and				
examination duration and scale	1 30 Hill			
	Electrical Engineering: Specialisation Cont	rol and Power Systems Engineering: Elective (Compulsory	
_	Mechatronics: Specialisation Intelligent Sy		, ,	
	Biomedical Engineering: Specialisation Im Biomedical Engineering: Specialisation Me Biomedical Engineering: Specialisation Ma	ificial Organs and Regenerative Medicine: Elective Compulsor plants and Endoprostheses: Elective Compulsor dical Technology and Control Theory: Compulsor angement and Business Administration: Electivical Complementary Course: Elective Compulsor	ory sory ive Compulsory	

Course L0660: Linear and No	onlinear System Identification
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	 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		Тур	Hrs/wk	СР
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3 3
	Prof. Herbert Werner	Recitation Section (Smail)	2	3
Module Responsible Admission Requirements	None			
Recommended Previous	None			
Knowledge	 Classical control (frequency response, root 	locus)		
Kilowicage	State space methods			
	 Linear algebra, singular value decomposition 	on		
Educational Objectives	After taking part successfully, students have read	ned the following learning results		
Professional Competence	The calling part baccessian, for a control have reach	ica and constant featuring results		
Knowledge				
Momeage	 Students can explain the significance of the 	e matrix Riccati equation for the solution of	LQ problems.	
	 They can explain the duality between opting 	nal state feedback and optimal state estima	tion.	
	 They can explain how the H2 and H-infinity 			
	They can explain how an LQG design proble	•		
	They can explain how model uncertainty common terms of the co	•		-
	They can explain how - based on the small	l gain theorem - a robust controller can gu	arantee stability	and performance
	an uncertain plant.	:		
	 They understand how analysis and synthes 	is conditions on reedback loops can be repr	esented as linear	matrix inequalities
Skills				
	Students are capable of designing and tuni	•		
	 They are capable of representing a H2 or H software tools for solving it. 	-infinity design problem in the form of a ge	neralized plant, a	and of using standa
	 They are capable of translating time and f 	requency domain specifications for control	loons into const	raints on closed lo
	sensitivity functions, and of carrying out a r		loops lilto collst	raints on closed-ic
	They are capable of constructing an LFT is		and of designi	ng a mixed-object
	robust controller.	ancertainey model for an ancertain system	, and or designin	ng a mixea especia
	They are capable of formulating analysis a	nd synthesis conditions as linear matrix inc	equalities (LMI), a	nd of using standa
	LMI-solvers for solving them.			
	 They can carry out all of the above using st 	andard software tools (Matlab robust contro	ol toolbox).	
D				
Personal Competence	Charles and the control of the contr			
•	Students can work in small groups on specific prol	*	aftuara dasuma	ntation) and use it
Autonomy	Students are able to find required information in solve given problems.	sources provided (lecture flotes, literature, s	software docume	ntation) and use it
	solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
A !	Communication Communication Intelligence From	in a single Florida Communication		
Assignment for the	Computer Science: Specialisation Intelligence Eng	, ,	ulcon	
Following Curricula	Electrical Engineering: Specialisation Control and Energy Systems: Core Qualification: Elective Com		uisory	
	Aircraft Systems Engineering: Specialisation Aircra	•		
	Mechatronics: Specialisation Intelligent Systems a			
	Mechatronics: Specialisation System Design: Elect	· · ·		
	Biomedical Engineering: Specialisation Artificial O		Compulsorv	
	Biomedical Engineering: Specialisation Implants a	•	1	
	Biomedical Engineering: Specialisation Medical Te		pulsory	
	Biomedical Engineering: Specialisation Manageme	• •		
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S	·		
	Product Development, Materials and Production: S			
	Theoretical Mechanical Engineering: Technical Co	mplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualific			

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

Module M0855: Marko	eting (Sales and Services / Innovati	on Marketing)		
Courses				
Title		Тур	Hrs/wk	СР
Marketing of Innovations (L2009)		Lecture	4	4
PBL Marketing of Innovations (L086	52)	Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje			
Admission Requirements	None			
Recommended Previous	Module International Business			
Knowledge	Basic understanding of business administr	ation principles (strategic planning, decision	on theory, pr	oject management,
	international business)			
	Bachelor-level Marketing Knowledge (Marketi		egies, Basics o	f Buying Behavior)
	Unerstanding the differences beweetn B2B at the description of the differences are a figure at the differences.			
	 Understanding of the importance of managin Good English proficiency; presentation skills 	g innovation in global industrial markets		
	Cook English profiterency, presentation skills			
Educational Objectives	After taking part successfully, students have reache	d the following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of in	novative poroducts and services		
	Approaches for analyzing the current market	situation and the future market development	i	
	The gathering of information about future customers			
	Concepts and approaches to integrate lead u			
	 Approaches and tools for ensuring customer- Marketing mix elements that take into consi 			
	services	deration the specime requirements and than	cinges or initio	rative products and
	 Pricing methods for new products and service 	es .		
	 The organization of complex sales forces and 	personal selling		
	Communication concepts and instruments for	new products and services		
Skills	Based on the acquired knowledge students will be a	ble to:		
	 Design and to evaluate decisions regarding n 	narketing and innovation strategies		
	 Analyze markets by applying market and tecl 	nnology portfolios		
	Conduct forecasts and develop compelling sc			
	Translate customer needs into concepts, pro	**	ully apply adv	anced methods for
	customer-oriented product and service develUse adequate methods to foster efficient diff			
	Choose suitable pricing strategies and comm			
	Make strategic sales decisions for products as			
	 Apply methods of sales force management (i. 	e. customer value analysis)		
Personal Competence				
· ·	The students will be able to			
,				
	 have fruitful discussions and exchange argun develop original results in a group 	nents		
	present results in a clear and concise way			
	carry out respectful team work			
Autonomy	The students will be able to			
	Acquire knowledge independents in the country	ific contact and to man this leaded as a set	hor now sees	lov problem fields
	 Acquire knowledge independently in the spec Consider proposed business actions in the fie 	,	her new compi	ex problem fields.
	Consider proposed business detions in the ne	of marketing and reneet on them.		
Workload in Hours	Independent Study Time 110, Study Time in Lecture	: 70		
Credit points				
Course achievement				
	Subject theoretical and practical work	articination		
Examination duration and scale	Written elaboration, excercises, presentation, oral p	агистраноп		
Assignment for the	Global Technology and Innovation Management & E	ntrepreneurship; Core Qualification: Compuls	orv	
Following Curricula	**		-	
	Mechanical Engineering and Management: Specialis		,	
	Biomedical Engineering: Specialisation Artificial Org	ans and Regenerative Medicine: Elective Com	ipulsory	
	Biomedical Engineering: Specialisation Implants and			
	Biomedical Engineering: Specialisation Medical Tech		ory	
	Biomedical Engineering: Specialisation Managemen	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		
	Prof. Christian Lüthje		
Language			
Cycle	I. 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		
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis		
	V. Customer-oriented Product and Service Engineering		
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting		
	VII. Pricing		
	Basics of Pricing, Value-based pricing, Pricing models		
	VIII. Sales Management		
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits		
	IX. Communications		
	Diffusion of Innovations, Communication Objectives, Communication Instruments		
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).		
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008		
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.		
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 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		

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

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame	ı	Practical Course	2	2
Module Responsible				
Admission Requirements				
	none, module "organic chemistry", modul	e "fundamentals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ve reached the following learning results		
Professional Competence Knowledge	enzymes and microorganisms, as well a rheology can be named and mass trans	ncepts of bioprocess engineering. They are able is to differentiate different types of inhibition, port processes in bioreactors can be explained rilization technology and downstream processing	The parameters of the students are	of stoichiometry a
Skills	After successful completion of this module, students should be able to describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on fermentation process analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaero to compare them as well as to apply them to current biotechnical problem propose solutions to complicated biotechnological problems and to deduce the corresponding models to explore new knowledge resources and to apply the newly gained contents identify scientific problems with concrete industrial use and to formulate solutions. to document and discuss their procedures as well as results in a scientific manner		wth inhibition on	
Personal Competence Social Competence Autonomy	take position to their own opinions and inc	its should be able to debate technical questions rease their capacity for teamwork in engineering its will be able to solve a technical problem in a plenum.	g and scientific envi	ronments.
Workload in Hours	Independent Study Time 96, Study Time i	Lecture 84		
Credit points				
Course achievement	Compulsory Bonus Form Yes 5 % Subject theoreti practical work	Description cal and		
Examination				
Examination duration and scale	90 min			
Assignment for the	General Engineering Science (German pro	gram, 7 semester): Specialisation Process Engine	eering: Compulsory	
Following Curricula		gram, 7 semester): Specialisation Bioprocess En		
-	Bioprocess Engineering: Core Qualification	: Compulsory	•	
	General Engineering Science (English prog	ram, 7 semester): Specialisation Process Engine	ering: Compulsory	
	General Engineering Science (English prog	ram, 7 semester): Specialisation Bioprocess Eng	ineering: Compulso	ry
		ificial Organs and Regenerative Medicine: Comp		
		plants and Endoprostheses: Elective Compulsory	•	
		dical Technology and Control Theory: Elective Co		
		nagement and Business Administration: Elective		
	rechnomathematics: Specialisation III. En	ineering Science: Elective Compulsory		

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, 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 En	gineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

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

Module M1143: Mech	anical Design Methodology			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Design Methodology (L	1523)	Lecture	3	4
Mechanical Design Methodology (L.	1524)	Recitation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Science-based working on product design cor	nsidering targeted application of specific pro-	duct design techniqu	es
Chille	Constitute has allien as a superior state of the said	NG		/ A
SKIIIS	Creative handling of processes used for scien various product design techniques following t		product design prod	ilems / Application of
	various product design techniques following t	neoretical aspects.		
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in I	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering: 9	Specialisation II. Product Development and P	roduction: Elective C	ompulsory
Following Curricula	Mechatronics: Specialisation System Design:	Elective Compulsory		
	Biomedical Engineering: Specialisation Artific	ial Organs and Regenerative Medicine: Elect	ve Compulsory	
	Biomedical Engineering: Specialisation Impla	nts and Endoprostheses: Elective Compulsor	/	
	Biomedical Engineering: Specialisation Medic	al Technology and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Manag	gement and Business Administration: Electiv	e Compulsory	
	Theoretical Mechanical Engineering: Specialis	sation Product Development and Production:	Elective Compulsory	
	Theoretical Mechanical Engineering: Technica	al Complementary Course: Elective Compulso	ory	

Course L1523: Mechanical De	esign 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 Do	esign 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: MED I	l: Introduction to Anatomy	
Courses		
Title	Typ Hrs/wk CP	
Introduction to Anatomy (L0384)	Lecture 2 3	
Module Responsible	Prof. Udo Schumacher	
Admission Requirements	None	
Recommended Previous	None	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system.	
	The students can describe the basic macroscopy and microscopy of those systems.	
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; the	
	can explain the relevance of structures and their functions in the context of widespread diseases.	
Personal Competence		
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.	
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui	
	the relevant knowledge themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points		
Course achievement		
Examination		
Examination duration and		
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic	
	Compulsory	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic	
	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	

avT	Lecture		
Hrs/wk			
СР			
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28	
Lecturer	Prof. Tobias Lange		
Language	DE		
Cycle			
Content	General Anatomy		
	1 st week:	The Eucaryote Cell	
	2 nd week:	The Tissues	
	z 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	
	7 th week:	Genito-urinary System	
	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/Michael	Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016	

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

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1280: MED I	II: Introduction to Physiology
Courses	
Title	Typ Hrs/wk CP
Introduction to Physiology (L0385)	Lecture 2 3
Module Responsible	Dr. Roger Zimmermann
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe the basics of the energy metabolism;
	 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, developmen
Danis and Comments and	of forces and vital functions) and relate them to similar technical systems.
Personal Competence	The students can conduct discussions in research and medicine on a technical level.
30Clai Competence	The students can find solutions to problems in the field of physiology, both analytical and metrological.
	The state his carrina solutions to problems in the field of physiology, both analytical and methological.
Autonomy	The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by
	themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	60 minutes
scale	
•	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics
	Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Conoral Engineering Science (English program, 7 computer): Specialisation Mechanical Engineering Focus Riemachanics
	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 t	Course L0385: Introduction to Physiology		
Тур	ecture		
Hrs/wk	2		
СР	3		
Workload in Hours	ndependent Study Time 62, Study Time in Lecture 28		
Lecturer	Dr. Gerhard Engler, Dr. Roger Zimmermann		
Language	DE		
Cycle	5oSe		
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: BIO I:	Experimental Methods in Biomechanics		
Courses			
Title	Тур	Hrs/wk	СР
Experimental Methods in Biomecha	anics (L0377) Lecture	2	3
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	It is recommended to participate in "Implantate und Frakturheilung" before attending	"Experimentelle Methoder	n".
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge	The students can describe the different ways how bones heal, and the requirements for the students can name different treatments for the spine and hollow bones under give		
	The students can describe different measurement techniques for forces and movemer given task.	nts, and choose the adequ	uate technique for a
Skills	The students can describe the basic handling of several experimental techniques used	d in biomechanics.	
Personal Competence			
Social Competence	The students can, in groups, solve basic experimental tasks.		
Autonomy	The students can, in groups, solve basic experimental tasks.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and	90 min		
scale			
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Me	chanical Engineering, Fo	cus Biomechanics:
Following Curricula	Compulsory		
	General Engineering Science (German program, 7 semester): Specialisation Biomedica	al Engineering: Compulsor	У
	General Engineering Science (English program, 7 semester): Specialisation Med	chanical Engineering, Fo	cus Biomechanics:
	Compulsory		
	General Engineering Science (English program, 7 semester): Specialisation Biomedical	l Engineering: Compulsory	/
	Mechanical Engineering: Specialisation Biomechanics: Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: El		
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compul	•	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Electiv		
	Biomedical Engineering: Specialisation Management and Business Administration: Elec	ctive Compulsory	
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0377: Experimental Methods in Biomechanics		
Тур	ture	
Hrs/wk	2	
СР	3	
Workload in Hours	dependent 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: BIO II	Artificial Joint Replacement				
Courses					
litle little		Тур	Hrs/wk	СР	
artificial Joint Replacement (L1306)		Lecture	2	3	
Module Responsible	Prof. Michael Morlock				
Admission Requirements	None				
Recommended Previous	Basic knowledge of orthopedic and surgical techn	iques is recommended.			
Knowledge					
Educational Objectives	After taking part successfully, students have read	hed 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.				
SKIIIS	The students can explain the advantages and dis	advantages of different kinds of endop	iotheses.		
Personal Competence					
Social Competence	The students are able to discuss issues related to	endoprothese with student mates and	I 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 Lectu	ro 28			
Credit points		10.20			
Course achievement					
Examination					
Examination duration and					
scale	90 111111				
Assignment for the	International Management and Engineering: Spec	rialisation II Process Engineering and B	Riotechnology: Flective	Compulsory	
Following Curricula	Materials Science: Specialisation Nano and Hybrid	, , , , , , , , , , , , , , , , , , ,	noteenhology. Licetive	compaisory	
. ccg cacaa	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 Managem	ent and Business Administration: Elect	ive Compulsory		
	Orientierungsstudium: Core Qualification: Electivo	e Compulsory			
	Theoretical Mechanical Engineering: Technical Co	cal Mechanical Engineering: Technical Complementary Course: Elective Compulsory			
	Theoretical Mechanical Engineering: Specialisation	n Bio- and Medical Technology: Electiv	e Compulsory		

Course L1306: Artificial Joint	Replacement		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
	Prof. Michael Morlock		
Language			
Cycle			
Content	Inhalt (deutsch)		
	1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)		
	2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)		
	3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)		
	4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)		
	5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)		
	6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)		
	7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)		
	8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)		
	9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß)		
Literature	Literatur:		
	Kapandji, I: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.		
	Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994		
	Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.		
	Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.		
	Sobotta und Netter für Anatomie der Gelenke		
	[176]		

Module M0845: Feedb	oack Control in Medical Techn	ology			
Courses					
Title		Тур	Hrs/wk	СР	
Feedback Control in Medical Techno	ology (L0664)	Lecture	2	3	
Module Responsible	Johannes Kreuzer				
Admission Requirements	None				
Recommended Previous	Basics in Control, Basics in Physiology				
Knowledge					
Educational Objectives	After taking part successfully, students hav	re reached the following learning results			
Professional Competence					
Knowledge	The lecture will introduce into the fascinating area of medical technology with the engineering point of view. Fundamentals human physiology will be similarly introduced like knowledge in control theory. Internal control loops of the human body will be discussed in the same way like the design of external closed loop system example in for anesthesia control.				
	The handling of PID controllers and modern controller like predictive controller or fuzzy controller or neural networks will lillustrated. 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 p	problems in small groups and present their res	sults		
Autonomy	Students are able to find necessary literature and to set it into the context of the lecture. They are able to continuously evaluat their knowledge and to take control of their learning process. They can combine knowledge from different courses to form a consistent whole.				
Workload in Hours	Independent Study Time 62, Study Time in	Lecture 28			
Credit points	3				
Course achievement	None				
Examination	Oral exam				
	20 min				
scale	ela de la companya de	difference floor of the control of t			
Assignment for the Following Curricula	Electrical Engineering: Specialisation Medic	al Technology: Elective Compulsory ol and Power Systems Engineering: Elective C	ompulsory		
Following Curricula	• • •	of and Power Systems Engineering: Elective C lants and Endoprostheses: Elective Compulsor			
		ficial Organs and Regenerative Medicine: Elect	•		
		agement and Business Administration: Elective			
		lical Technology and Control Theory: Compuls			
	3 3 1, 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	-		

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

Courses Fitle Advanced Topics in Control (L0661) Advanced Topics in Control (L0662) Module Responsible Prof. Herbert Werner	Тур					
Advanced Topics in Control (L0661) Advanced Topics in Control (L0662)	Tvp					
Advanced Topics in Control (L0662)		Hrs/wk	СР			
	Lecture	2	3			
	Recitation Section (small)	2	3			
*						
Admission Requirements None Recommended Previous H-infinity optimal control, mixed-sensitivity design, linear recommendations.	matrix inequalities					
Knowledge	matrix mequanties					
Educational Objectives After taking part successfully, students have reached the	following learning results					
Professional Competence	3 3					
 They can explain the representation of nonlinear sy They can explain how stability and performance cor They can explain how gridding techniques can be u 	 Students can explain the advantages and shortcomings of the classical gain scheduling approach They can explain the representation of nonlinear systems in the form of quasi-LPV systems They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis technical contents. 					
systems • They can explain the convergence properties of first						
to an actuator/sensor array • They can explain (in outline) the extension of the						
scheduled controllers; they can do this using polyto They are able to use standard software tools (Matla	 Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity designs scheduled controllers; they can do this using polytopic, LFT or general LPV models They are able to use standard software tools (Matlab robust control toolbox) for these tasks Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dyname 					
Personal Competence Social Competence Students can work in small groups and arrive at joint result	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					
Workload in Hours Independent Study Time 124, Study Time in Lecture 56						
Credit points 6						
Course achievement None						
Examination Oral exam Examination duration and 30 min						
Examination duration and 30 min						
Assignment for the Computer Science: Specialisation Intelligence Engineering	· Flective Compulsory					
Assignment for the Computer Science, Specialisation intelligence Engineering	, ,	ulsorv				
Following Curricula Electrical Engineering: Specialisation Control and Power Sy		,				
Following Curricula Electrical Engineering: Specialisation Control and Power Sy Aircraft Systems Engineering: Specialisation Aircraft Syste	Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory					
Aircraft Systems Engineering: Specialisation Aircraft Syste	ilis. Elective Compulsory	International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory				
Aircraft Systems Engineering: Specialisation Aircraft Syste Aircraft Systems Engineering: Specialisation Avionic Syste	• •	ory				
Aircraft Systems Engineering: Specialisation Aircraft Syste Aircraft Systems Engineering: Specialisation Avionic Syste	II. Mechatronics: Elective Compuls	ory				
Aircraft Systems Engineering: Specialisation Aircraft Syste Aircraft Systems Engineering: Specialisation Avionic Syste International Management and Engineering: Specialisation	n II. Mechatronics: Elective Compuls ipulsory	ory				
Aircraft Systems Engineering: Specialisation Aircraft System Aircraft Systems Engineering: Specialisation Avionic Syste International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com	II. Mechatronics: Elective Compuls pulsory tics: Elective Compulsory	ory				
Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Avionic Syste International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technology	n II. Mechatronics: Elective Compuls ipulsory itics: Elective Compulsory prostheses: Elective Compulsory y and Control Theory: Elective Com	pulsory				
Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Avionic Syste International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technology Biomedical Engineering: Specialisation Management and Engineerin	II. Mechatronics: Elective Compuls ipulsory itics: Elective Compulsory prostheses: Elective Compulsory y and Control Theory: Elective Com Business Administration: Elective Co	pulsory				
Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Avionic Syste International Management and Engineering: Specialisation Mechatronics: Specialisation System Design: Elective Com Mechatronics: Specialisation Intelligent Systems and Robo Biomedical Engineering: Specialisation Implants and Endo Biomedical Engineering: Specialisation Medical Technology	II. Mechatronics: Elective Compuls ipulsory itics: Elective Compulsory prostheses: Elective Compulsory y and Control Theory: Elective Com Business Administration: Elective Co d Regenerative Medicine: Elective Co	pulsory				

Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0661: Advanced Top	oics in Control				
Тур	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28				
Lecturer	of. 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	Washington Market and Table Contains				
	Werner, H., Lecture Notes "Advanced Topics in Control" Calcuting of calculate recognity and a supplied to a supplied t				
	Selection of relevant research papers made available as pdf documents via StudIP				

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

Specialization Management and Business Administration

Module M0623: Intell	igent Systems	in Medicine				
Courses						
Title			1	Гур	Hrs/wk	СР
Intelligent Systems in Medicine (L0331)				ecture	2	3
Intelligent Systems in Medicine (L0334)			F	Project Seminar	2	2
Intelligent Systems in Medicine (L0	333)		F	Recitation Section (small)	1	1
Module Responsible		efer				
Admission Requirements	None					
Recommended Previous	 principles of m 	nath (algebra, analysis/ca	alculus)			
Knowledge	principles of st	tochastics				
	 principles of p 	rogramming, Java/C++ a	nd R/Matlab			
	advanced prog	gramming skills				
Educational Objectives	After taking part suc	cessfully, students have r	reached the following	learning results		
Professional Competence	31			,		
Knowledge	The students are ab	le to analyze and solve o	clinical treatment pla	nning and decision suppor	t problems using	methods for search
	optimization, and pla	nning. They are able to e	explain methods for o	classification and their resp	ective advantage	s and disadvantages
	in clinical contexts. The students can compare different methods for representing medical knowledge. They car in the context of clinical data and explain challenges due to the clinical nature of the data and its acquisition					an evaluate methods
						n and due to privacy
	and safety requireme	ents.				
Skills	The students can give	ve reasons for selecting a	and adapting metho	ds for classification, regres	sion, and predict	ion. They can assess
	The students can give reasons for selecting and adapting methods for classification, regression, and prediction. They can assess the methods based on actual patient data and evaluate the implemented methods.					
Personal Competence						
•	The students discuss	the results of other arou	ins provide helpful fo	eedback and can incoorpor	ate feedback into	their work
Social competence	The students discuss	the results of other grou	ips, provide neipidi it	ceaback and can incoorpor	ate recuback into	then work.
Autonomy	The students can ref	lect their knowledge and	d document the resu	lts of their work. They can	present the resu	Its in an appropriate
	manner.					
Workload in Hours	Independent Study T	ime 110, Study Time in L	ecture 70			
Credit points	6					
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and scale	90 minutes					
Assignment for the	Computer Science: S	pecialisation Intelligence	Engineering: Flective	e Compulsory		
=	-	g: Specialisation Medical				
. ccimiy carricula	_			ngineering and Robotics: E	lective Compulsor	y
		lisation Intelligent System			, , ,	-
	-			erative Medicine: Elective	Compulsory	
	Biomedical Engineer	ing: Specialisation Implar	nts and Endoprosthes	es: Elective Compulsory		
	Biomedical Engineer	ing: Specialisation Medica	al Technology and Co	ntrol Theory: Elective Com	pulsory	
	Biomedical Engineer	ing: Specialisation Manag	gement and Business	Administration: Elective Co	ompulsory	
				urse: Elective Compulsory		
	Theoretical Mechanic	cal Engineering: Specialis	ation Bio- and Medic	al Technology: Elective Cor	npulsory	

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	

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

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

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	d Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
	(goals, utilities, environments). They can decan be discussed in terms of decision proble world scenarios, students can summarize he formalism in static and dynamic settings. It settings, with and with complete access to solving (partially observable) Markov decisions Students can identify techniques for simult desired states. Students can explain coording of equilibria, social choice functions, voting processed states and select an appropriate agent a students can derive decision trees and applinetworks/dynamic Bayesian networks and different sampling techniques for simplified best action or policies for concrete settings.	define intelligence in terms of rational behavior, scribe the main features of environments. The notlems and algorithms for solving these problems, ow Bayesian networks can be employed as a kno n addition, students can define decision making to the state of the environment. In this context, so ion problems, and they can recall techniques for taneous localization and mapping, and can explanation problems and decision making in a multi-approtocol, and mechanism design techniques. Carchitecture for concrete agent application scenarily basic optimization techniques. For those application apply bayesian reasoning for simple queries. In multi-agent situations students will apply tech decision making students will apply different votires.	otion of adversariation of adv	al agent cooperate uncertainty in restation and reason mple and sequencribe techniques value of informatiniques for achievem of different typed agent applicated as or create Bayes on name and applicts can compute g different equilibit
Personal Competence				
•				
Social Competence	Students are able to discuss their solutions t	to problems with others. They communicate in Eng	glish	
		to problems with others. They communicate in Enganding of complex concepts by solving varaints of		ns
	Students are able of checking their understa	anding of complex concepts by solving varaints of		ns
Autonomy	Students are able of checking their understa Independent Study Time 124, Study Time in	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours	Students are able of checking their understa Independent Study Time 124, Study Time in 6	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understa Independent Study Time 124, Study Time in 6	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination Examination and	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes	anding of complex concepts by solving varaints of		ns
Workload in Hours Credit points Course achievement Examination Examination and scale	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	anding of complex concepts by solving varaints of	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cot Biomedical Engineering: Specialisation Artifice	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Compulsory	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cott Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory	concrete problem	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Composition Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medical Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Sp	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory cal Technology and Control Theory: Elective Compulsory	e Compulsory Compulsory	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Course Biomedical Engineering: Specialisation Implates Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Managements:	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory	e Compulsory Compulsory	ns

Tvn	Lecture
	2
	4
	Independent Study Time 92, Study Time in Lecture 28
Cycle	
Content	wisc —
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, produce 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-cas 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, Marko assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation special cases: hidden Markov models, Kalman filters, Exact inferences and approximations 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 externali mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwai Theorem
Literature	 Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 1 11, 13-17 Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005
	3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridg University Press, 2009

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

Module M1230: Selec	ted Topics of Biomedical Engineering	g - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	663)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	cs (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
		••		
	Biomedical Engineering: Specialisation Management a	and Business Administration: Elective Co	ompulsorv	

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

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

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

Course L1588: Development	and Regulatory Approval of 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	90 Minuten
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	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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).

Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
xamination duration and	90 Minuten
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 ein 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 wirt 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	schriftliche ausarbeitung und Vortrag (20 min)	
scale		
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	90 Minuten		
scale			
Lecturer	Prof. Claus Emmelmann		
Language	DE		
Cycle	ViSe		
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		

Tom	CS II		
Тур	Lecture		
Hrs/wk			
СР			
Workload in Hours	ndependent Study Time 92, Study Time in Lecture 28		
Examination Form	Klausur		
Examination duration and			
scale			
Lecturer	Prof. Michael Schlüter		
Language	DE		
Cycle	WiSe		
Content	Differential equations for momentum-, heat and mass transfer		
	Examples for simplifications of the Navier-Stokes Equations		
	Unsteady momentum transfer		
	Free shear layer, turbulence and free jets		
	Flow around particles - Solids Process Engineering		
	Coupling of momentum and heat transfer - Thermal Process Engineering		
	Rheology – Bioprocess Engineering		
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering		
	Flow threw porous structures - heterogeneous catalysis		
	Pumps and turbines - Energy- and Environmental Process Engineering		
	Wind- and Wave-Turbines - Renewable Energy		
	Introduction into Computational Fluid Dynamics		
Literature	1. Prover LL, Crundlagen der Einnhagen, und Mahrahagenströmungen Verlag Cauerländer, Aarau Frankfurt (M. 1071		
	 Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972. 		
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.		
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelber		
	2006.		
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.		
	6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungs		
	Springer Verlag, Berlin, Heidelberg, New York, 2006.		
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GV		
	Fachverlage GmbH, Wiesbaden, 2008.		
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007		
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne		
	GWV Fachverlage GmbH, Wiesbaden, 2009.		
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.		
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring		
	Verlag, Berlin, Heidelberg, 2008.		
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.		
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.		

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

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

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

Module M0746: Micro	system Engineering			
Courses				
Title Microsystem Engineering (L0680)		Typ Lecture	Hrs/wk	CP 4
Microsystem Engineering (L0682)	Duf Musfulkum	Project-/problem-based Learning	2	2
-	Prof. Manfred Kasper			
	None			
	Basic courses in physics, mathematics and electric engineering			
Knowledge	After taking part suggestibly students have reached the following	na loorning rocults		
-	After taking part successfully, students have reached the following	ng learning results		
Professional Competence Knowledge	The students know about the most important technologies and actuators.	d materials of MEMS as well as	their applicatio	ns in sensors and
Skills	Students are able to analyze and describe the functional be microsystems.	haviour of MEMS components a	and to evaluate	e the potential of
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group	and to present the results accord	ingly.	
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with other fields.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description No 10 % Presentation			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the	Electrical Engineering: Core Qualification: Compulsory			
Following Curricula	Computational Science and Engineering: Specialisation Systems	Engineering and Robotics: Elective	ve Compulsory	
	International Management and Engineering: Specialisation II. Ele	-	pulsory	
	International Management and Engineering: Specialisation II. Me			
	International Management and Engineering: Specialisation II. Ele		pulsory	
	International Management and Engineering: Specialisation II. Me Mechanical Engineering and Management: Specialisation Mechat			
	Mechanical Engineering and Management: Specialisation Mechan			
	Mechatronics: Specialisation System Design: Elective Compulsor			
	Mechatronics: Specialisation System Design: Elective Compulsor			
	Biomedical Engineering: Specialisation Artificial Organs and Rege	enerative Medicine: Elective Com	pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosthe	eses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Technology and 0	Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management and Busines	·	ulsory	
	Microelectronics and Microsystems: Core Qualification: Elective C			
	Theoretical Mechanical Engineering: Technical Complementary C	' '		
	Theoretical Mechanical Engineering: Specialisation Bio- and Medi			
	Theoretical Mechanical Engineering: Specialisation Bio- and Medi	icai Technology: Elective Compul	sory	

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

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
	• Engineering Mechanics			
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 Vibrat	ion Theory and develop them furt	her.	
Skills	Students are able to denote methods of Vibration Theory and develop them further.			
Personal Competence				
Social Competence	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vibration Theory.			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Energy Systems: Core Qualification: Elective Compulsory			
Following Curricula	International Management and Engineering: Specialisatio	n II. Mechatronics: Elective Compu	ulsory	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compulsor	гу	
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial Organs a	•	e Compulsory	
	Biomedical Engineering: Specialisation Implants and Endo			
	Biomedical Engineering: Specialisation Medical Technolog	•		
	Biomedical Engineering: Specialisation Management and		Compulsory	
	Product Development, Materials and Production: Core Qu			
	Naval Architecture and Ocean Engineering: Core Qualifica			
	Theoretical Mechanical Engineering: Core Qualification: E	• •		
	Theoretical Mechanical Engineering: Technical Compleme	intary Course: Elective Compulsor	у	

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 Schwingunger	
	Springer Verlag, 2013.	

Module MU/68: Micro	systems Technology in Theory and Pr	actice		
Courses				
Title		Тур	Hrs/wk	СР
Microsystems Technology (L0724)		Lecture	2	4
Microsystems Technology (L0725)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, mechanics and semicondu	ictor technology		
Knowledge				
Educational Objectives	After taking part successfully, students have reached th	ne following learning results		
Professional Competence				
Knowledge	Students are able			
	to annual to the control of the cont	.hi	II	
	to present and to explain current fabrication tec microsensors and microactuators, as well as the integra		ily methods to	or the fabrication
	to explain in details operation principles of microse	nsors and microactuators and		
	to discuss the potential and limitation of microsyste	ems in application.		
Skills	Students are capable			
	to analyze the feesibility of microsystems			
	to analyze the feasibility of microsystems,			
	to develop process flows for the fabrication of micro	ostructures and		
	to apply them.			
	то арргу спети.			
Personal Competence Social Competence	Students are able to prepare and perform their lab exp of audience.	eriments in team work as well as to prese	ent and discus	s the results in fro
Autonomy	None			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement		ription		
	Yes None Subject theoretical and Stuc practical work präs	dierenden führen in Kleingruppen ein La sentiert und diskutiert die Theorie sowie o dem gesamten Kurs.		, ,
Examination	Oral exam			
Examination duration and				
scale				
	Electrical Engineering: Specialisation Nanoelectronics a	nd Microsystems Technology: Elective Co.	mpulsorv	
_	Electrical Engineering: Specialisation Medical Technolog			
3	Computational Science and Engineering: Specialisation		ve Compulsor	y
	International Management and Engineering: Specialisat			
	Biomedical Engineering: Specialisation Artificial Organs		pulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Technol	ogy and Control Theory: Elective Compuls	ory	
	Biomedical Engineering: Specialisation Management an	d Business Administration: Elective Comp	ulsory	
	Microelectronics and Microsystems: Core Qualification:	Flective Compulsory		

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	EN
Cycle	WiSe
Content	 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 undercrutting, 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, SUB, 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, piezoresitivity; pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process; accelerometer: piezoresistive, plezoelectric and capacitive; angular rate sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, clark electrode, enzyme electrode,
Literature	M. Madou: Fundamentals of Microfabrication, CRC Press, 2002
Encorature	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

	e Elements Methods			
Courses				
Title		Тур	Hrs/wk	СР
Finite Element Methods (L0291)		Lecture	2	3
Finite Element Methods (L0804)		Recitation Section (large)	2	3
Module Responsible	Prof. Otto von Estorff			
Admission Requirements	None			
Recommended Previous	Mechanics I (Statics, Mechanics of Materials) and Mechanic	s II (Hydrostatics, Kinematics, Dyn	amics)	
Knowledge	Mathematics I, II, III (in particular differential equations)			
Educational Objectives	After taking part successfully, students have reached the f	ollowing learning results		
Professional Competence	31			
•	The students possess an in-depth knowledge regarding	the derivation of the finite eleme	ent method and	are able to give
, and meage	overview of the theoretical and methodical basis of the me		and meened and	are able to give
Skills	The students are capable to handle engineering problems	by formulating suitable finite ele	ments, assemblin	g the correspondi
	system matrices, and solving the resulting system of equa	tions.		
Personal Competence				
Social Competence	Students can work in small groups on specific problems to	arrive at joint solutions.		
Autonomy	The students are able to independently solve challenging	ng computational problems and o	develop own finit	e element routin
,	Problems can be identified and the results are critically scr			
	,			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	· · · · · ·			
Course achievement		ion		
Course achievement	No 20 % Midterm			
Examination	Written exam			
Examination duration and	120 min			
scale				
Assignment for the	Civil Engineering: Core Qualification: Compulsory			
•	Energy Systems: Core Qualification: Elective Compulsory			
3 · · · · ·	Aircraft Systems Engineering: Specialisation Aircraft System	ns: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation Air Transporta			
	Aircraft Systems Engineering: Specialisation Aircraft System	ns: Elective Compulsory		
	Aircraft Systems Engineering: Specialisation Air Transporta	tion Systems: Elective Compulsory		
	International Management and Engineering: Specialisation	II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering: Specialisation	II. Product Development and Produ	uction: Elective Co	ompulsory
	International Management and Engineering: Specialisation	II. Mechatronics: Elective Compuls	ory	
	International Management and Engineering: Specialisation	II. Product Development and Produ	uction: Elective Co	ompulsory
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Implants and Endop	prostheses: Compulsory		
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Com	pulsory	
	Piomodical Engineering, Specialisation Artificial Organs an		Compulsory	
	Bioinedical Engineering. Specialisation Artificial Organs an	d Regenerative Medicine: Elective (
	Product Development, Materials and Production: Core Qual		30pu.30.y	
		ification: Compulsory	50pui56.y	
	Product Development, Materials and Production: Core Qual	ification: Compulsory e: Elective Compulsory	pussy	

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

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

Module M0814: Techr	nology Management
Courses	
Title	Typ Hrs/wk CP
Technology Management (L0849)	Project-/problem-based Learning 3 3
Technology Management Seminar	
Module Responsible	Prof. Cornelius Herstatt
Admission Requirements	
	Bachelor knowledge in business management
Knowledge	
	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowieage	Students will gain deep insights into:
	International R&D-Management
	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	The course aims to:
Personal Competence Social Competence Autonomy	Interact within a team Raise awareness for globabl issues
	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and	90 minutes
scale	
Assignment for the	Global Innovation Management: Core Qualification: Compulsory
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
	biomedical Engineering. Specialisation Management and business Administration: Compusory

Course L0849: Technology 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 Incovation Management, Elgar Research Collection, Northhampton (MA) 2011	

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

Module M0846: Contr	ol Systems Theory and Design			
Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Design	n (L0656)	Lecture	2	4
Control Systems Theory and Design		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Introduction to Control Systems			
	After taking part successfully, students have rea	ached the following learning results		
Professional Competence	Their taking pare successionly, stodents have rec	active the following learning results		
Knowledge				
	 Students can explain how linear dynami response to initial states or external excit They can explain the system properties estimation, respectively They can explain the significance of a min 	cation as trajectories in state space controllability and observability, and their renimal realisation	elationship to stat	e feedback and state
	They can explain observer-based state fe		acking and disturb	oance rejection
	 They can extend all of the above to multi- They can explain the z-transform and its 			
		transfer function models of discrete-time sy	stems	
	They can explain the experimental identifies be solved by solving a normal equation They can explain how a state space model.			ification problem can
Skills	 Students can transform transfer function models into state space models and vice versa They can assess controllability and observability and construct minimal realisations They can design LQG controllers for multivariable plants They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate They can identify transfer function models and state space models of dynamic systems from experimental data They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink) 			
•	Students can work in small groups on specific problems to arrive at joint solutions. Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use i when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning progress.			
	Independent Study Time 124, Study Time in Lec	ture 56		
Credit points	б			
Course achievement	None			
Examination				
Examination duration and	120 min			
scale Assignment for the	Computer Science: Specialisation Intelligence Er	ngineering: Elective Compulsory		
=	Electrical Engineering: Core Qualification: Comp			
	Energy Systems: Core Qualification: Elective Cor			
	Aircraft Systems Engineering: Specialisation Airc	craft Systems: Compulsory		
	Aircraft Systems Engineering: Specialisation Avi	·	-	
	Computational Science and Engineering: Specia			
	International Management and Engineering: Spe International Management and Engineering: Spe			
	Mechanical Engineering and Management: Spec			
	Mechatronics: Core Qualification: Compulsory			
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation Implants			
	Biomedical Engineering: Specialisation Medical			
	Biomedical Engineering: Specialisation Manager Product Development, Materials and Production		ompuisory	
	Theoretical Mechanical Engineering: Core Qualif			

7	Locture	
	Lecture	
Hrs/wk		
	4	
	ndependent Study Time 92, Study Time in Lecture 28	
Lecturer	Prof. Herbert Werner	
Language	EN	
Cycle	WiSe	
Content	State space methods (single-input single-output)	
	State space models and transfer functions, state feedback	
	Coordinate basis, similarity transformations	
	Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem	
	Controllability and pole placement	
	State estimation, observability, Kalman decomposition	
	Observer-based state feedback control, reference tracking	
	Transmission zeros	
	Optimal pole placement, symmetric root locus	
	Multi-input multi-output systems	
	Transfer function matrices, state space models of multivariable systems, Gilbert realization	
	Poles and zeros of multivariable systems, minimal realization	
	Closed-loop stability	
	Pole placement for multivariable systems, LQR design, Kalman filter	
	Digital Control	
	Discrete-time systems: difference equations and z-transform	
	Discrete-time state space models, sampled data systems, poles and zeros	
	Frequency response of sampled data systems, choice of sampling rate	
	System identification and model order reduction	
	Least squares estimation, ARX models, persistent excitation	
	Identification of state space models, subspace identification	
	Balanced realization and model order reduction	
	Case study	
	Modelling and multivariable control of a process evaporator using Matlab and Simulink	
	Software tools	
	Matlab/Simulink	
Literature	Worner H. Locture Notes: Central Systems Theory and Design"	
	Werner, H., Lecture Notes "Control Systems Theory and Design" T. Kailath "Linear Systems" Proptice Hall 1990	
	T. Kailath "Linear Systems", Prentice Hall, 1980 K. L. Actrom, P. Wittenmark, "Computer Controlled Systems", Prentice Hall, 1997.	
	 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

Module M0867: Produ	iction Planning & Control a	nd Digital Enterprise		
Courses				
litle		Тур	Hrs/wk	СР
he Digital Enterprise (L0932)		Lecture	2	2
roduction Planning and Control (L	0929)	Lecture	2	2
roduction Planning and Control (L	0930)	Recitation Section (small)	1	1
xercise: The Digital Enterprise (L0	933)	Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	y Management		
Knowledge				
Educational Objectives	After taking part successfully, students	have reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of th	e module in detail and take a critical position to them		
	·	applying models and methods from the module to indu		
Personal Competence	3	, , ,		
•	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
	Independent Study Time 96, Study Time in Lecture 84			
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and				
scale				
Assignment for the	International Management and Enginee	ering: Specialisation II. Product Development and Prod	uction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Sp	pecialisation Production and Logistics: Elective Compu	ılsory	
	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: Compulso	ry	
	Product Development, Materials and Pro	oduction: Specialisation Product Development: Electiv	e Compulsory	
	Product Development, Materials and Pro	oduction: Specialisation Production: Compulsory		
	Product Development, Materials and Pro	oduction: Specialisation Materials: Elective Compulsor	ТУ	
	Theoretical Mechanical Engineering: Sp	ecialisation Product Development and Production: Ele	ctive Compulsory	
	Theoretical Mechanical Engineering: Te	chnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	
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 Pl	ourse L0930: Production Planning and Control		
Тур	Recitation Section (small)		
Hrs/wk	1		
СР	1		
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14		
Lecturer	Prof. Hermann Lödding		
Language	DE		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

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

Module M0921: Electi	ronic Circuits fo	r Medical Appli	cations			
Courses						
Title Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl	lications (L1056)			Typ Lecture Recitation Section (small) Practical Course	Hrs/wk 2 1	CP 3 2
Module Responsible				Tractical Course		1
Admission Requirements						
Recommended Previous	†	trical engineering				
Knowledge		3 3				
Educational Objectives	After taking part succ	essfully, students have	reached the followi	ng learning results		
Professional Competence						
Knowledge	Students can e Students are al Students can e Students can d Students can e	ole to explain the build- xemplify the communic escribe the special feat xplain the functions of	-up of an action pote cation between neur tures of low-noise ar prostheses, e. g. an	ation transfer by the central ential and its propagation al- ons and electronic devices nplifiers for medical applica artificial hand of cochlea implants and arti	ong an axon	
Skills	 Students can calculate the time dependent voltage behavior of an action potential Students can give scenarios for further improvement of low-noise and low-power signal acquisition. Students can develop the block diagrams of prosthetic systems Students can define the building blocks of electronic systems for an articifial eye. 					
Personal Competence Social Competence						
Autonomy	Students are a necessary. Students can b Students can h	reak down their work ir andle the complex data	n appropriate work p a structures of bioele	their knowledge and to do backages and schedule their ectrical experiments without les and situations of experin	work in a realistic	
Workload in Hours	Independent Study Ti	me 124, Study Time in	Lecture 56			
Credit points		Form	Description			
Course achievement	Yes None No None	Subject theoretical practical work Excercises	· ·			
Examination						
Examination duration and						
Scale Assignment for the	Electrical Engineering	· Specialization Mod:	L Technology: Flacti	ve Compulsory		
Following Curricula		: Specialisation Medica : Specialisation Medica				
		•		enerative Medicine: Elective	Compulsory	
				eses: Elective Compulsory	-	
	Biomedical Engineering	ng: Specialisation Medic	cal Technology and (Control Theory: Compulsory		
	_			ss Administration: Elective C		
				ics Complements: Elective C		
				ical Technology: Elective Co		
				Course: Elective Compulsory ical Technology: Elective Co		
	Theoretical Methalica	ar Errymoermy. Speciall	Sation Pio- alla Mea	icai recimology. Elective Co	пиратовт у	

Course L0696: Electronic Circ	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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 Cir	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g.,	in the module Mechanics II (forces and	l moments, stres	s, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain e	nergy).		
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to	calculate the mechanical behavior of m	naterials.	
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.			
Personal Competence				
Social Competence	The students are able to develop solutions, to present 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 Time in Lecture 56	5		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Co	mpulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation			
	Mechatronics: Technical Complementary Course: Elect			
	Biomedical Engineering: Specialisation Artificial Organs		Compulsory	
	Biomedical Engineering: Specialisation Implants and En			
	Biomedical Engineering: Specialisation Medical Techno		-	
	Biomedical Engineering: Specialisation Management and Product Development, Materials and Production: Core (inpuisory	
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Fechnical Comple			
	co. ca.ca recharical Engineering. core Qualification	. Elective Compaisory		

Course L1533: Continuum Mo	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: Continuum Mo	echanics Exercise
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	 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: Mater	rial Modeling	
Courses		
Title	Typ Hrs/wk CP	
Material Modeling (L1535)	Lecture 2 3	
Material Modeling (L1536)	Recitation Section (small) 2 3	
Module Responsible	Prof. Christian Cyron	
Admission Requirements	None	
Recommended Previous	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (fo	rces
Knowledge	and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws	
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowle	edge
	to various problems of material science and evaluate the corresponding material models.	
Personal Competence		
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.	
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and s	olve
	problems in the area of materials modeling and acquire the knowledge required to this end.	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	
Credit points		
Course achievement		
Examination		
Examination duration and	45 min	
scale		
Assignment for the	Computational Science and Engineering: Specialisation Scientific Computing: Elective Compulsory	
Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory	
	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory	
	Product Development, Materials and Production: Core Qualification: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	

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

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

Module M1199: Adva	nced Functional Materials
Courses	
Title	Typ Hrs/wk CP
Advanced Functional Materials (L16	Seminar 2 6
Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particul
	metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.
Chille	The students will be able to select material configurations according to the technical needs and, if necessary, to design no
SKIIIS	materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview of
	modern materials science, which enables them to select optimum materials combinations depending on the technic
	applications.
Personal Competence	
Social Competence	The students are able to present solutions to specialists and to develop ideas further.
Autonomy	The students are able to
,	
	assess their own strengths and weaknesses.
	gather new necessary expertise by their own.
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and	30 min
scale	
Assignment for the	Materials Science: Core Qualification: Compulsory
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

Module M1241: Selec	ted Topics of Biomedical Engineering	g - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	563)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
ntroduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and I	Endoprostheses: Elective Compulsory		
i ollowing curricula				
Tollowing Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	

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

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

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

Course L1588: Development and Regulatory Approval of 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	90 Minuten	
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	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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	90 Minuten	
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	schriftliche ausarbeitung und Vortrag (20 min)
scale	
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	90 Minuten
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 Mechanics II	
Тур	
Hrs/wk	
СР	
Workload in Hours	
Examination Form	
Examination duration and	
scale	
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	WiSe
Content	
	Differential equations for momentum-, heat and mass transfer Type play for simplifications of the Navier Stakes Equations
	 Examples for simplifications of the Navier-Stokes Equations Unsteady momentum transfer
	Free shear layer, turbulence and free jets
	Flow around particles - Solids Process Engineering
	Coupling of momentum and heat transfer - Thermal Process Engineering
	Rheology – Bioprocess Engineering
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering
	Flow threw porous structures - heterogeneous catalysis
	Pumps and turbines - Energy- and Environmental Process Engineering
	Wind- and Wave-Turbines - Renewable Energy
	Introduction into Computational Fluid Dynamics
Literature	
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.
	4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelbei
	2006.
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.
	6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömung
	Springer Verlag, Berlin, Heidelberg, New York, 2006.
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GV
	Fachverlage GmbH, Wiesbaden, 2008.
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne
	GWV Fachverlage GmbH, Wiesbaden, 2009.
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring
	Verlag, Berlin, Heidelberg, 2008.
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.
	13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.

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

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

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

Module M1279: MED I	II: Introduction to Biochemistry and Molecular Biology	
Courses		
Title	Typ Hrs/wk CP	
Introduction to Biochemistry and M	Molecular Biology (L0386) Lecture 2 3	
Module Responsible	Prof. Hans-Jürgen Kreienkamp	
Admission Requirements	None	
Recommended Previous	s None	
Knowledge	3	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can	
	describe basic biomolecules;	
	explain how genetic information is coded in the DNA;	
	explain the connection between DNA and proteins;	
Skills	s The students can	
	• recognize the importance of malecular parameters for the course of a disease.	
	 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	
	explain the relevance of those 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.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	s 3	
Course achievement	t None	
Examination	Written exam	
Examination duration and	d 60 minutes	
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
Following Curricula		iomechanics:
	Compulsory	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Bi	iomechanics:
	Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	Mechanical Engineering Science (Engins) program, 7 semester): Specialisation Biomedical Engineering. 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 t	Course L0386: Introduction to Biochemistry and Molecular Biology	
Тур	Lecture	
Hrs/wk	2	
СР	3	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Lecturer	Prof. Hans-Jürgen Kreienkamp	
Language	DE	
Cycle	WiSe	
Content		
Literature	Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage	
	Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008	

Module M1333: BIO I:	Implants and Fracture Healing
Courses	
Title	Typ Hrs/wk CP
Implants and Fracture Healing (L03	376) Lecture 2 3
Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.
Personal Competence	
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	90 min
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics
Following Curricula	Compulsory
	General Engineering Science (German program, 7 semester): 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 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
	Orientierungsstudium: Core Qualification: Elective Compulsory
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1334: BIO II	: Biomaterials			
Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical technique	s is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	The students can describe the materials of the humar	body and the materials being us	sed in medical engineerir	ng, and their fields of
	use.			
Chille	The students can explain the advantages and disadva	ntages of different kinds of biom	atorials	
SKIIIS	The students can explain the advantages and disadva	intages of different kinds of blom	iateriais.	
Personal Competence				
Social Competence	The students are able to discuss issues related to ma	terials being present or being us	ed for replacements with	student mates and
	the teachers.			
Autonomy	The students are able to acquire information on their	own. They can also judge the info	ormation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	}		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Specialis	ation II. Process Engineering and	Biotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid Ma	terials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	ns and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techn	• • • • • • • • • • • • • • • • • • • •		
	Biomedical Engineering: Specialisation Management a			
	Theoretical Mechanical Engineering: Technical Comple	·	•	
	Theoretical Mechanical Engineering: Specialisation Bio	o- and Medical Technology: Electi	ive Compulsory	

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

	ners			
Courses				
Title		Тур	Hrs/wk	CP
Structure and Properties of Polyme		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous	Basics: chemistry / physics / material scien	ce		
Knowledge				
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence				
Knowledge	Students can use the knowledge of plastics	s and define the necessary testing and anal	ysis.	
	They can explain the complex relationships	s structure-property relationship and		
	the interactions of chemical structure of th	a polymers, including to explain paighborin	a contoute (o a custaine	bility onvironment
	the interactions of chemical structure of th protection).	e polymers, including to explain heighborni	ig contexts (e.g. sustaina	ibility, environment
	protection).			
Skills	Students are capable of			
	- using standardized calculation methods	s in a given context to mechanical prop	erties (modulus, strena	th) to calculate a
	evaluate the different materials.	g	(,
	- selecting appropriate solutions for mecha	anical recycling problems and sizing examp	le stiffness, corrosion re	sistance.
Personal Competence				
Social Competence	Students can			
	and and find a discount field between	de la companya de la		
	- arrive at funded work results in heteroger	nius groups and document them.		
	- provide appropriate feedback and handle	feedback on their own performance constr	uctively.	
Autonomy	Students are able to			
	- assess their own strengths and weakness	es		
	assess their own strengths and weakness	C3.		
	- assess their own state of learning in spec	ific terms and to define further work steps	on this basis.	
	- assess possible consequences of their pro	ofessional activity.		
		· · · · · · · · · · · · · · · · · · ·		
Workload in Hours	Independent Study Time 124, Study Time i	n Lecture 56		
Credit points				
Course achievement	None			
Examination	Written exam			
Examination duration and	180 min			
scale				
Assignment for the	Materials Science: Specialisation Engineeri			
Following Curricula	Biomedical Engineering: Specialisation Imp		lantina Canada Israel	
	Biomedical Engineering: Specialisation Arti	•		
	Biomedical Engineering: Specialisation Mar Biomedical Engineering: Specialisation Med			
	Product Development, Materials and Produ	• • • • • • • • • • • • • • • • • • • •		
	Product Development, Materials and Produ			
	Product Development, Materials and Produ	•		
	Theoretical Mechanical Engineering: Techn			
	Theoretical Mechanical Engineering: Specia		•	

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

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

Module M0632: Rege	nerative Medicii	е			
Courses					
Title			Тур	Hrs/wk	СР
Regenerative Medicine (L0347)			Seminar	2	3
Lecture Tissue Engineering - Reger	nerative Medicine (L1664)		Seminar	2	3
Module Responsible	Prof. Ralf Pörtner				
Admission Requirements	None				
Recommended Previous	None				
Knowledge					
Educational Objectives	After taking part succe	sfully, students have re	eached the following learning results		
Professional Competence					
Knowledge	After successful comp	etion of the module stu	idents will be able to describe the basic	methods of regenera	tive medicine and t
	explain the use of the	ssue cells for different i	methods of tissue engineering. They are	able to give a basic ov	erview of methods f
	the cultivation of anim	I and human cells.			
	The students can ou	ine the actual concep	ts of Tissue Engineering and regenera	tive medicine and ca	an explain the bas
	udnerlying principles of				
CI:II-	A 64		la-sk		
SKIIIS	After successful comp	tion of the module stud	ents are		
	able to use med	cal databases for acquir	rierung and presentation of relevant up-to	o-date data independe	ently
	 able to present 	heir work results in the	form of presentations		
	 able to carry ou 	basic cell culture metho	ods and the corresponding analysis indep	endently	
	able to analyse	nd evaluate current res	search topics for Tissue Engineering and r	regenerative medicine	-
Personal Competence					
Social Competence		rk together as a team v	with 2-4 students to solve given tasks an	d discuss their results	in the plenary and t
	defend them.				
	Students are able to re	lect their work orally ar	nd discuss it with other students and teac	hers.	
Autonomy					
	After completion of	nis modulo narticinant	es will be able to solve a technical n	roblem in teams of	annroy 2.4 nerson
	After completion of this module, participants will be able to solve a technical problem in teams of approx. 2-4 persor independently including a presentation of the results.				
	macpendently merdan	a presentation of the f	esuits.		
Workload in Hours	Independent Study Tir	e 124, Study Time in Le	ecture 56		
Credit points					
Course achievement		Form	Description	tocal for lacture carde	
Evamination	Yes 20 %	Written elaboration	Ausarbeitung zu Ringvorlesung / pro	tocor for lecture series	•
Examination		cussion (20 min)			
Examination duration and scale	Oral presentation + di	.ussi0ii (50 Min)			
Assignment for the	Riomedical Engineerin	· Specialisation Implant	s and Endonrostheses: Elective Compuler	ory	
•	_				
Following Curricula	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory				
Following Curricula	-	•	•		

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 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: Bioel	ectromagnetics: Principles an	d Applications			
Courses					
Title		Тур		Hrs/wk	СР
Bioelectromagnetics: Principles and		Lecture		3	5
Bioelectromagnetics: Principles and	d Applications (L0373)	Recitation Sec	tion (small)	2	1
Module Responsible	Prof. Christian Schuster				
Admission Requirements	None				
	Basic principles of physics				
Knowledge					
Educational Objectives	After taking part successfully, students ha	vo reached the following learning re-	culto		
Professional Competence	Arter taking part successibility, students has	ve reactied the following learning res	suits		
•	Students can explain the basic principles,	relationships and methods of bioele	ctromagnetics i e	the quantifica	ation and application
Miowicage	of electromagnetic fields in biological tiss	·	-	•	
	them corresponding to wavelength and f		·		
	techniques for characterization of electro				
	diagnostic utilization of electromagnetic fie	elds in medical technology.			
Skills	Students know how to apply various method	ods to characterize the behavior of e	electromagnetic fi	elds in biologic	al tissue. In order
	do this they can relate to and make use	of the elementary solutions of Max	well's Equations.	They are able	to assess the mo
	important effects that these models pred				
	frequency, respectively, and they can ana				
	predictions. They are able to evaluate the	effects of electromagnetic fields for	therapeutic and d	liagnostic appli	cations and make
	appropriate choice.				
Porconal Compotonce					
Personal Competence	Students are able to work together on su	higgs related tacks in small groups	Thou are able to	procent their	recults offestively
30Clai Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).				
	English (e.g. during small group exercises)				
Autonomy	Students are capable to gather informat	ion from subject related, profession	nal publications a	and relate that	t information to th
Ź	context of the lecture. They are able to m				
	other lectures (e.g. theory of electromag	netic fields, fundamentals of electr	ical engineering	/ physics). The	y can communica
	problems and effects in the field of bioelec	tromagnetics in English.			
	Independent Study Time 110, Study Time 6	ın Lecture 70			
Credit points Course achievement	Compulsory Bonus Form	Description			
Course achievement	Yes 10 % Presentation	,			
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Medi	cal Technology: Elective Compulsory	/		
Following Curricula				atibility: Electi	ve Compulsory
_	International Management and Engineering				
	Biomedical Engineering: Specialisation Arti	• .	-		
	Biomedical Engineering: Specialisation Imp	plants and Endoprostheses: Elective	Compulsory		
	Biomedical Engineering: Specialisation Med	dical Technology and Control Theory	: Elective Compul	sory	
	Biomedical Engineering: Specialisation Ma	nagement and Business Administrat	ion: Elective Com	pulsory	
	Theoretical Mechanical Engineering: Techr	nical Complementary Course: Electiv	e Compulsory		
	Theoretical Mechanical Engineering: Specia	alisation Bio- and Medical Technolog	y: Elective Compu	ulsory	

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

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

Module M0630: Robo	tics and Naviga	ation in Med	licine			
Courses						
Title	(, , , , , , , , , , , , , , , , , , ,			Тур	Hrs/wk	СР
Robotics and Navigation in Medicin Robotics and Navigation in Medicin				Lecture Project Seminar	2	3 2
Robotics and Navigation in Medicin				Recitation Section (small)	1	1
Module Responsible		efer		,		
Admission Requirements	None					
Recommended Previous						
Knowledge		nath (algebra, ana				
	principles of pi solid R or Matl	rogramming, e.g.,	, in Java or C++			
	• Solid R or Mati	ad skills				
Educational Objectives	After taking part succ	cessfully, student	s have reached the follo	wing learning results		
Professional Competence						
Knowledge	The students can ex	plain kinematics	and tracking systems	in clinical contexts and illustr	ate systems and	their components in
	detail. Systems can	be evaluated wit	th respect to collision (detection and safety and reg	julations. Student	s can assess typical
	systems regarding de	esign and limitati	ions.			
Skills	The students are able	e to design and e	valuate navigation syste	ems and robotic systems for me	edical applications	i.
			,	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
Personal Competence						
Social Competence	The students discuss	the results of oth	ner groups, provide help	ful feedback and can incoorpor	ate feedback into	their work.
Autonomy	The students can ref	lect their knowle	dge and document the	results of their work. They car	present the resu	ilts in an appropriate
	manner.					
Workload in Hours	Independent Study T	ime 110, Study T	ime in Lecture 70			
Credit points						
Course achievement		Form	Description			
	Yes 10 % Yes 10 %	Presentation Written elabora	ation			
Examination		Written elabora	ation			
Examination duration and	+					
examination duration and scale	90 minutes					
Assignment for the	Computer Science: S	necialisation Intel	lligence Engineering: Ele	ective Compulsory		
Following Curricula	·		Medical Technology: Elec			
. cemily carricula	-			Electrical Engineering: Elective	Compulsory	
	_		t Systems and Robotics		, , ,	
	·	-	•	egenerative Medicine: Elective	Compulsory	
	Biomedical Engineeri	ing: Specialisatior	Implants and Endopros	theses: Elective Compulsory		
	Biomedical Engineeri	ing: Specialisation	n Medical Technology an	d Control Theory: Elective Com	npulsory	
	Biomedical Engineeri	ing: Specialisation	n Management and Busi	ness Administration: Elective C	ompulsory	
				n Product Development: Electiv		
				n Production: Elective Compuls	•	
	·		•	n Materials: Elective Compulsor	ТУ	
				y Course: Elective Compulsory		
	i neoretical Mechanic	cai Engineering: S	pecialisation Bio- and M	edical Technology: Elective Co	mpulsory	

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

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

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

Module M0634: Introd	duction into Me	dical Technology an	d Systems			
Courses						
Title			T	/p	Hrs/wk	СР
Introduction into Medical Technolog	gy and Systems (L0342)		-	cture	2	3
Introduction into Medical Technolog	gy and Systems (L0343)		Pro	oject Seminar	2	2
Introduction into Medical Technolog	gy and Systems (L1876)		Re	ecitation Section (large)	1	1
Module Responsible	Prof. Alexander Schlae	efer				
Admission Requirements	None					
Recommended Previous	principles of math (alg	gebra, analysis/calculus)				
Knowledge	principles of stochast	ics				
	principles of programi	ming, R/Matlab				
Educational Objectives	After taking part succ	essfully, students have reach	ed the following	learning results		
Professional Competence						
Knowledge	The students can ex	plain principles of medical t	echnology, inclu	ding imaging systems,	computer aided s	urgery, and medical
	information systems.	They are able to give an over	view of regulator	y affairs and standards	in medical technolo	gy.
Skills	The students are able	to evaluate systems and me	dical devices in t	he context of clinical an	nlications	
Skills	The stadents are able	to evaluate systems and me	aicai acvices iii e	ne context of chilical ap	prications.	
Personal Competence						
Social Competence	The students describe	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.				
Autonomy	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate					
,	manner.					
Workload in Hours		me 110, Study Time in Lectur	e 70			
Credit points	6	Form				
Course achievement	Compulsory Bonus Yes 10 %	Written elaboration	Description			
	Yes 10 %	Presentation				
Examination	Written exam	. resementation				
Examination duration and	90 minutes					
scale						
Assignment for the	General Engineering S	Science (German program, 7	semester): Specia	alisation Biomedical Eng	ineering: Compulso	iry
Following Curricula	Computer Science: Sp	ecialisation Computer and Sc	oftware Engineeri	ng: Elective Compulsory	/	
	Electrical Engineering	: Core Qualification: Elective	Compulsory			
	General Engineering S	Science (English program, 7 s	emester): Specia	lisation Biomedical Engi	neering: Compulsoi	У
	Computational Science	e and Engineering: Specialisa	tion II. Mathema	tics & Engineering Scien	ice: Elective Compu	lsory
	Computational Science	e and Engineering: Specialisa	tion Computer S	cience: Elective Compul	sory	
	Computational Science	e and Engineering: Specialisa	tion Engineering	Sciences: Elective Com	pulsory	
	Biomedical Engineering	g: Specialisation Artificial Or	gans and Regene	rative Medicine: Elective	e Compulsory	
	-	ng: Specialisation Implants an	•			
	_	ng: Specialisation Medical Tec				
	-	ng: Specialisation Managemer			Compulsory	
	Technomathematics:	Specialisation III. Engineering	Science: Elective	e Compulsory		

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

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

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

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
,	After taking part successfully, students have reached the f	ollowing learning results		
Professional Competence				
Knowledge	Students are able to reflect existing terms and concepts	in Nonlinear Dynamics and t	o develop and resea	arch new terms and
a	concepts.			
	Students are able to apply existing methods and procesure	es of Nonlinear Dynamics and to	develop novel meth	ods and procedures.
Personal Competence				
, , , , , , , , , , , , , , , , , , ,	Students can reach working results also in groups.			al a le alle a constant
,	Students are able to approach given research tasks individ	ually and to identify and follow	up novel research ta	sks by themselves.
	Independent Study Time 124, Study Time in Lecture 56			
Credit points				
Course achievement				
Examination				
Examination duration and	2 Hours			
scale	Aircraft Systems Engineering, Specialisation Aircraft System	ms. Flastive Compulsory		
•	Aircraft Systems Engineering: Specialisation Aircraft Systen International Management and Engineering: Specialisation	, ,	ulcon	
Following Curricula	Mechanical Engineering and Management: Specialisation		•	
	Mechatronics: Specialisation System Design: Elective Comp	•	,, y	
	Mechatronics: Specialisation Intelligent Systems and Robot	•		
	Biomedical Engineering: Specialisation Artificial Organs and	, ,	ve Compulsory	
	Biomedical Engineering: Specialisation Implants and Endop	•		
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective	Compulsory	
	Product Development, Materials and Production: Core Qual	ification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complemen	tary Course: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Core Qualification: Ele	ctive Compulsory		

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

Courses					
Title		Тур	Hrs/wk	СР	
Semiconductor Technology (L0722		Lecture	4	4	
Semiconductor Technology (L0723)	Practical Course	2	2	
Module Responsible	Prof. Hoc Khiem Trieu				
Admission Requirements	None				
	Basics in physics, chemistry, material science and semic	onductor devices			
Knowledge					
Educational Objectives	After taking part successfully, students have reached the	e following learning results			
Professional Competence					
Knowledge					
	Students are able				
	to describe and to explain current fabrication techni	ques for Si and GaAs substrates	,		
	to discuss in details the relevant fabrication	processes, process flows and	the impact thereof o	n the fabrication	
	semiconductor devices and integrated circuits and				
	to precent integrated precess flows				
	to present integrated process flows.				
Skills					
SKIIIS					
	Students are capable				
	to analyze the impact of process parameters on the	nrocessing results			
	to analyze the impact of process parameters on the	processing results,			
	to select and to evaluate processes and				
	to develop process flows for the fabrication of semiconductor devices.				
	to develop process nows for the labilitation of service	oridactor acvices.			
Personal Competence					
Social Competence					
Social competence					
	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in from				
	of audience.				
Autonomy					
	Independent Study Time 96, Study Time in Lecture 84				
Credit points					
Course achievement					
Examination					
Examination duration and	30 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics ar	d Microsystems Technology: Ele	ective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Artificial Organs				
3	Biomedical Engineering: Specialisation Implants and Enc	•			
	Biomedical Engineering: Specialisation Medical Technology				
	Biomedical Engineering: Specialisation Management and	Business Administration: Election	ve Compulsory		
	Microelectronics and Microsystems: Specialisation Micro	electronics Complements: Electi	ve Compulsory		

0722: Semiconducto	
Тур	Lecture
Hrs/wk	4
CP Jorkload in Hours	4 Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
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 proces Wafer fabrication (process flow, specification, SOI) Fabrication processes Doping (energy band diagram, doping, doping by alloying, doping by diffusion: transport processes, doping profile, hig order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dama annealing and equipment) Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kinet influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs)
	 Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kineti temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniqu APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacu evaporation, sputtering)
	 Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximand projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique a electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, elect beam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchi backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation)
	Process integration (CMOS process, bipolar process)
	 Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical conta wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	D. van Zanti Microckin Eakrication - A Practical Cuido to Comiconduster Processing McCraw Hill
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	Introduction to control systems			
	Control theory and design			
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge	Students can explain humanoid robots.			
	Students learn to apply basic control concepts f	for different tasks in humanoid r	obotics.	
Skills				
Skills	 Students acquire knowledge about selected asp 	ects of humanoid robotics, base	ed on specified literature	
	 Students generalize developed results and pres 			
	Students practice to prepare and give a present	tation		
Personal Competence				
Social Competence				
	 Students are capable of developing solutions in They are able to provide appropriate feedback 			
	• They are able to provide appropriate reedback	and nandle constructive criticisi	ii oi tileli owii results	
Autonomy	 Students evaluate advantages and drawbacks 	s of different forms of present	ation for specific tasks a	and select the best
	solution	or amerene ronne er present	acion for specific cashs c	and beleet the best
	Students familiarize themselves with a scientif	fic field, are able of introduce i	t and follow presentation	s of other students,
	such that a scientific discussion develops			
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28			
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	thm:mechatronics: Specialisation Intelligent Systems and Foundation Intellige	Robotics: Elective Compulsory		
Following Curricula	Mechatronics: Specialisation System Design: Elective			
	Biomedical Engineering: Specialisation Artificial Organ	-		
	Biomedical Engineering: Specialisation Implants and E	·	•	
	Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management a			
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Core Qualification		,	

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

Module M0838: Linea	r and Nonlinear System Ident	ifikation		
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Identi	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Classical control (frequency respons State space methods Discrete-time systems Linear algebra, singular value decon Basic knowledge about stochastic pr	nposition		
Educational Objectives	After taking part successfully, students have	ve reached the following learning results		
Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	Students can explain the general finonlinear model structures They can explain how multilayer per They can explain how an approxima They can explain the idea of subspans Students are capable of applying the models for dynamic systems They are capable of implementing a They are capable of applying subspans They can do the above using standa Students can work in mixed groups on specific standards.	ramework of the prediction error method and receptron networks are used to model nonlinea te predictive control scheme can be based on ce identification and its relation to Kalman reach the prediction error method to the experimental nonlinear predictive control scheme based or ace algorithms to the experimental identification rd software tools (including the Matlab System cific problems to arrive at joint solutions.	r dynamics neural network mode ilisation theory ental identification of n a neural network mo- on of linear models for n Identification Toolbo	linear and nonlinear del r dynamic systems x)
	solve given problems.			
	Independent Study Time 62, Study Time in	Lecture 28		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the	Electrical Engineering: Specialisation Contr	ol and Power Systems Engineering: Elective C	ompulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Sys Mechatronics: Specialisation System Desig			
		ficial Organs and Regenerative Medicine: Elec	tive Compulsorv	
		plants and Endoprostheses: Elective Compulso		
		dical Technology and Control Theory: Compuls	•	
	Biomedical Engineering: Specialisation Mar	nagement and Business Administration: Electiv	ve Compulsory	
	Theoretical Mechanical Engineering: Techn	ical Complementary Course: Elective Compuls	sory	
	Theoretical Mechanical Engineering: Core (Qualification: Elective Compulsory		

Course L0660: Linear and No	onlinear System Identification
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Herbert Werner
Language	EN
Cycle	SoSe
Content	 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					
Γitle		Тур	Hrs/wk	СР	
Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Lecture Recitation Section (small)	2	3	
	· 	Recitation Section (Smail)	2	3	
Module Responsible					
Admission Requirements					
Recommended Previous	Classical control (frequency response, root locus	5)			
Knowledge	State space methods				
	Linear algebra, singular value decomposition				
Educational Objectives	After taking part successfully, students have reached t	the following learning results			
Professional Competence					
Knowledge	Students can explain the significance of the mat	trix Riccati equation for the solution of	LQ problems.		
	They can explain the duality between optimal st				
	They can explain how the H2 and H-infinity norm	ns are used to represent stability and p	erformance cons	straints.	
	They can explain how an LQG design problem can	an be formulated as special case of an	H2 design proble	m.	
	They can explain how model uncertainty can be	e represented in a way that lends itself	to robust control	ler design	
	They can explain how - based on the small gain	n theorem - a robust controller can gu	arantee stability	and performance	
	an uncertain plant.				
	They understand how analysis and synthesis con	nditions on feedback loops can be repr	esented as linear	matrix inequalitie	
g					
Skills	Students are capable of designing and tuning LC	QG controllers for multivariable plant m	odels.		
	They are capable of representing a H2 or H-infir	nity design problem in the form of a ge	neralized plant, a	and of using stand	
	software tools for solving it.				
	They are capable of translating time and frequ	ency domain specifications for control	loops into const	raints on closed-lo	
	sensitivity functions, and of carrying out a mixed	d-sensitivity design.			
	They are capable of constructing an LFT uncer	rtainty model for an uncertain system	, and of designing	ng a mixed-object	
	robust controller.				
	They are capable of formulating analysis and synthesis conditions as linear matrix inequalities (LMI), and of using standard				
	LMI-solvers for solving them.				
	They can carry out all of the above using standa	ard software tools (Matlab robust contro	ol toolbox).		
Personal Competence					
•	Students can work in small groups on specific problem	s to arrive at joint solutions			
Autonomy					
Autonomy	solve given problems.	es provided (lecture flotes, literature, s	software docume	illation) and use it	
	Solve given problems.				
Workload in Hours	Independent Study Time 124, Study Time in Lecture 5	6			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the					
Following Curricula					
	Energy Systems: Core Qualification: Elective Compulsory				
	Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory				
	Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory				
	Mechalionics: Specialisation System Design: Elective (Compulson		
			corripuisory		
	Biomedical Engineering: Specialisation Artificial Organs	•			
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En	ndoprostheses: Elective Compulsory	nulcor:		
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno	ndoprostheses: Elective Compulsory ology and Control Theory: Elective Com			
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management an	ndoprostheses: Elective Compulsory ology and Control Theory: Elective Com nd Business Administration: Elective Co	ompulsory		
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management an Product Development, Materials and Production: Speci	ndoprostheses: Elective Compulsory ology and Control Theory: Elective Com nd Business Administration: Elective Co alisation Product Development: Electiv	ompulsory e Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management an Product Development, Materials and Production: Speci Product Development, Materials and Production: Speci	ndoprostheses: Elective Compulsory ology and Control Theory: Elective Com nd Business Administration: Elective Co alisation Product Development: Electiv alisation Production: Elective Compulso	ompulsory e Compulsory ory		
	Biomedical Engineering: Specialisation Artificial Organs Biomedical Engineering: Specialisation Implants and En Biomedical Engineering: Specialisation Medical Techno Biomedical Engineering: Specialisation Management an Product Development, Materials and Production: Speci	ndoprostheses: Elective Compulsory blogy and Control Theory: Elective Com nd Business Administration: Elective Co alisation Product Development: Electivalisation Production: Elective Compulsor alisation Materials: Elective Compulsor	ompulsory e Compulsory ory		

Course L0658: Optimal and Robust Control			
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	SoSe		
Content	 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 		

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

Module M0855: Marko	eting (Sales and Service	es / Innovation Marke	eting)		
Courses					
Title			Тур	Hrs/wk	СР
Marketing of Innovations (L2009)			Lecture	4	4
PBL Marketing of Innovations (L086	2)		Project-/problem-based Learning	1	2
Module Responsible	Prof. Christian Lüthje				
Admission Requirements	None				
Recommended Previous	Module International Busine	ess			
Knowledge	Basic understanding of b	usiness administration princip	oles (strategic planning, decisio	on theory, proje	ect management,
	international business)				
			nts, Market and Competitor Strate	egies, Basics of I	3uying Behavior)
		es beweetn B2B and B2C marke			
	 Good English proficiency; p 	tance of managing innovation	in global industrial markets		
	- Good English proficiency, p	resentation skins			
Educational Objectives	After taking part successfully, stu	dents have reached the following	ng learning results		
Professional Competence					
Knowledge	Students will have gained a deep	understanding of			
	Specific characteristics in t	ne marketing of innovative por	oducts and services		
	 Approaches for analyzing t 	ne current market situation and	I the future market development		
	 The gathering of information 	n about future customer needs	and requirements		
			r needs into product and service		
			the development of new produc		
	services	at take into consideration the	specific requirements and chall	enges of fillova	tive products and
	 Pricing methods for new pr 	oducts and services			
		x sales forces and personal sel	ling		
	 Communication concepts a 	nd instruments for new produc	ts and services		
Skills	Based on the acquired knowledge	students will be able to:			
	Design and to evaluate dec	isions regarding marketing and	l innovation strategies		
	 Analyze markets by applying 	g market and technology portf	olios		
		elop compelling scenarios as a			
			marketable offers and successf	ully apply advar	iced methods for
	customer-oriented product	·	vative products and convices		
	Use adequate methods to foster efficient diffusion of innovative products and services Chapter suitable pricing strategies and communication activities for innovations.				
	 Choose suitable pricing strategies and communication activities for innovations Make strategic sales decisions for products and services (i.e. selection of sales channels) 				
	Apply methods of sales for	e management (i.e. customer	value analysis)		
Personal Competence					
•	The students will be able to				
	have fruitful discussions an	3 3			
	 develop original results in a present results in a clear a 				
	carry out respectful team v	•			
Autonomy	The students will be able to				
		alcords to the control of			a markle of Co. Co.
	, , , , , , , , , , , , , , , , , , , ,	idently in the specific context a s actions in the field of marketi	and to map this knowledge on oth	ner new complex	problem fields.
	Consider proposed busines	s actions in the neid of marketi	ing and reflect on them.		
Workload in Hours	Independent Study Time 110, Stu	dy Time in Lecture 70			
Credit points					
Course achievement					
	Subject theoretical and practical v				
Examination duration and scale	Written elaboration, excercises, p	esentation, oral participation			
Assignment for the	Global Technology and Innovation	Management & Entrepreneurs	hip: Core Qualification: Compulse	orv	
Following Curricula	International Management and Er			•	
3	Mechanical Engineering and Mana				
	Biomedical Engineering: Specialis	•		pulsory	
	Biomedical Engineering: Specialis	ation Implants and Endoprosthe	eses: Elective Compulsory		
	Biomedical Engineering: Specialis			ory	
	Biomedical Engineering: Specialis	ation Management and Busines	ss 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	I. 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	
	• Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis	
	7. 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	

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

Module M1143: Mech	anical Design Methodology			
Courses				
Title		Тур	Hrs/wk	СР
Mechanical Design Methodology (L	1523)	Lecture	3	4
Mechanical Design Methodology (L	1524)	Recitation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
Knowledge	Science-based working on product design co	onsidering targeted application of specific prod	uct design technique	es
Skills				lone / Application of
SKIIIS	creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.			
	various product design techniques following	theoretical aspects.		
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and	30 min			
scale				
Assignment for the	International Management and Engineering:	Specialisation II. Product Development and Pr	oduction: Elective Co	ompulsory
Following Curricula	Mechatronics: Specialisation System Design	: Elective Compulsory		
	Biomedical Engineering: Specialisation Artifi	cial Organs and Regenerative Medicine: Electiv	ve Compulsory	
	Biomedical Engineering: Specialisation Impla	ants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medi	cal Technology and Control Theory: Elective Co	ompulsory	
	Biomedical Engineering: Specialisation Mana	agement and Business Administration: Elective	Compulsory	
	Theoretical Mechanical Engineering: Special	isation Product Development and Production: I	Elective Compulsory	
	Theoretical Mechanical Engineering: Technic	cal Complementary Course: Elective Compulso	ry	

Course L1523: Mechanical Do	esign 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 Do	esign 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

Courses				
Title		Тур	Hrs/wk	СР
Bioprocess Engineering - Fundame		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (large)	2	1
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible				
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "	fundamentals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence Knowledge	Students are able to describe the basic conc enzymes and microorganisms, as well as rheology can be named and mass transpo	epts of bioprocess engineering. They are able to differentiate different types of inhibition. ort processes in bioreactors can be explained ization technology and downstream processing	The parameters of	of stoichiometry
Skills	After successful completion of this module, students should be able to describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process			
	distinguish between scale-up criteria to compare them as well as to apply to propose solutions to complicated block to explore new knowledge resources a identify scientific problems with concri	echnological problems and to deduce the corre	erobic, aerobic as	well as microaero
Personal Competence Social Competence Autonomy	After completion of this module participants take position to their own opinions and incre	should be able to debate technical questions ase their capacity for teamwork in engineering will be able to solve a technical problem in a enum.	and scientific envi	ronments.
W. H. H. H.	Lada and State Time Of State Time in I			
	Independent Study Time 96, Study Time in L	ecture 04		
Credit points Course achievement		Description and		
Examination	Written exam			
Examination duration and scale				
Assignment for the	General Engineering Science (German progra	am, 7 semester): Specialisation Process Engine	ering: Compulsory	
Following Curricula		am, 7 semester): Specialisation Bioprocess Eng		
3	Bioprocess Engineering: Core Qualification: 0		3	-
		m, 7 semester): Specialisation Process Engine	ering: Compulsory	
		m, 7 semester): Specialisation Bioprocess Engi		ry
	General Engineering Science (English progra		5	
			Ilsory	
	Biomedical Engineering: Specialisation Artific	cial Organs and Regenerative Medicine: Compu	llsory	
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla	cial Organs and Regenerative Medicine: Compu ints and Endoprostheses: Elective Compulsory	•	
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic	cial Organs and Regenerative Medicine: Compu ants and Endoprostheses: Elective Compulsory cal Technology and Control Theory: Elective Co	mpulsory	
	Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medic	cial Organs and Regenerative Medicine: Compu ents and Endoprostheses: Elective Compulsory cal Technology and Control Theory: Elective Co gement and Business Administration: Elective	mpulsory	

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, 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 En	gineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

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

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

Course L0384: Introduction t	Course L0384: Introduction to Anatomy				
	Lecture				
Hrs/wk	2				
СР	3				
Workload in Hours		Time 62, Study Time in Lecture 28			
	Prof. Tobias Lange				
Language					
	SoSe General Anatomy				
Content	1 st week:	The Eucaryote Cell			
	2 nd week: 3 rd week:	The Tissues Cell Cycle, Basics in Development			
	4 th week:	Musculoskeletal System			
	5 th week: 6 th week:	Cardiovascular System Respiratory System			
	7 th week:	Genito-urinary System			
	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	el Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016			

Module M1280: MED I	II: Introduction to Physiology
Courses	
Title	Typ Hrs/wk CP
Introduction to Physiology (L0385)	Lecture 2 3
Module Responsible	Dr. Roger Zimmermann
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe the basics of the energy metabolism;
	describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.
G	
Skills	The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development
Personal Competence	of forces and vital functions) and relate them to similar technical systems.
-	The students can conduct discussions in research and medicine on a technical level.
Social Competence	The students can find solutions to problems in the field of physiology, both analytical and metrological.
Autonomy	
	themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	None
Examination	Written exam
Examination duration and	60 minutes
scale	
•	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics:
	Compulsory Floating Engineering Specialization Medical Technology Floating Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics:
	Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory
	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, Dr. Roger Zimmermann	
Language	DE	
Cycle	SoSe	
Content		
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme	
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier	

Module M1278: MED I	l: Introduction to Radiology and Radiation Therapy
Courses	
Title	Typ Hrs/wk CP
Introduction to Radiology and Radio	
Module Responsible	
Admission Requirements Recommended Previous	
Knowledge	Note
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).
	The students can describe the patients' passage from their initial admittance through to follow-up care.
	Diagnostics
	The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).
	The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.
	The students can choose the right treatment method depending on the patient's clinical history and needs.
	The student can explain the influence of technical errors on the imaging techniques.
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	Therapy
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.
	The students can use the therapeutic principle (effects vs adverse effects)
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).
	Diagnostics
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.
Personal Competence	
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.
	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	
Examination Examination duration and	90 minutes
scale	130 minutes
Assignment for the Following Curricula	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1332: BIO I:	Experimental Methods in Biomec	hanics		
Courses				
Title		Тур	Hrs/wk	СР
Experimental Methods in Biomecha	nics (L0377)	Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	It is recommended to participate in "Implantate u	nd Frakturheilung" before attending "	Experimentelle Methode	en".
Knowledge				
Educational Objectives	After taking part successfully, students have reac	hed the following learning results		
Professional Competence				
Knowledge	The students can describe the different ways how	· ·		
	The students can name different treatments for t	ne spine and nollow bones under give	n fracture morphologies	
	The students can describe different measuremen	t techniques for forces and movemen	ts, and choose the adeq	uate technique for a
	given task.			
Skills	The students can describe the basic handling of s	everal experimental techniques used	in biomechanics.	
Personal Competence				
	The students can, in groups, solve basic experime	ental tasks.		
,	The students can, in groups, solve basic experime			
Workload in Hours	Independent Study Time 62, Study Time in Lectur	re 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	General Engineering Science (German program	m, 7 semester): Specialisation Mec	hanical Engineering, F	ocus Biomechanics:
Following Curricula	Compulsory			
	General Engineering Science (German program, 7			
	General Engineering Science (English program	n, 7 semester): Specialisation Mec	hanical Engineering, F	ocus Biomechanics:
	Compulsory			
	General Engineering Science (English program, 7	•	Engineering: Compulsor	У
	Mechanical Engineering: Specialisation Biomecha Biomedical Engineering: Specialisation Artificial C		active Compulsory	
	Biomedical Engineering: Specialisation Artificial C			
	Biomedical Engineering: Specialisation Implants a	·	•	
	Biomedical Engineering: Specialisation Medical Re	•		
	Technomathematics: Specialisation III. Engineering		compaisory	

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

1odule M1335: BIO II	: Artificial Joint Replacement			
Courses				
itle		Тур	Hrs/wk	СР
artificial Joint Replacement (L1306)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical tech	iniques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have rea	ched the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds of art	cificial limbs.		
CI:II-	The shirt share are similar than a discount and di			
SKIIIS	The students can explain the advantages and di	sadvantages or different kinds of endopr	otneses.	
Personal Competence				
Social Competence	The students are able to discuss issues related t	o endoprothese with student mates and	the teachers.	
Autonomy	The students are able to acquire information on	their own. They can also judge the infor	mation with respect to	its credibility
Workload in Hours	Independent Study Time 62, Study Time in Lectu	ure 28		
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Spe	ecialisation II. Process Engineering and B	iotechnology: Elective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybr			
	Biomedical Engineering: Specialisation Artificial	Organs and Regenerative Medicine: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation Implants	and Endoprostheses: Compulsory		
	Biomedical Engineering: Specialisation Medical 7	Гесhnology and Control Theory: Elective	Compulsory	
	Biomedical Engineering: Specialisation Managen	nent and Business Administration: Electi	ve Compulsory	
	Orientierungsstudium: Core Qualification: Electiv	ve Compulsory		
	Theoretical Mechanical Engineering: Technical C	Complementary Course: Elective Compuls	sory	
	Theoretical Mechanical Engineering: Specialisati	on Bio- and Medical Technology: Elective	e Compulsory	

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

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

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

ourses				
itle dvanced Topics in Control (L0661)	Typ Lecture	Hrs/wk 2	CP 3
dvanced Topics in Control (L0662		Recitation Section (small)	2	3
Module Responsible		,		
Admission Requirements	H-infinity optimal control, mixed-sensitivity design	linear matrix inequalities		
Knowledge		i, illear matrix mequalities		
Educational Objectives		had the following learning requite		
		ned the following learning results		
Professional Competence				
Knowledge	Students can explain the advantages and s	hortcomings of the classical gain schedulir	ig approach	
	They can explain the representation of non	linear systems in the form of quasi-LPV sys	tems	
	They can explain how stability and perform	ance conditions for LPV systems can be for	mulated as LMI co	onditions
	They can explain how gridding techniques	can be used to solve analysis and synthesis	problems for LPV	/ systems
	They are familiar with polytopic and LFT	representations of LPV systems and sor	me of the basic s	synthesis techniq
	associated with each of these model struct	ures		
	Students can explain how graph theoreti	ic concepts are used to represent the co	ommunication top	oology of multiag
	systems			
	They can explain the convergence properti	es of first order consensus protocols		
	They can explain analysis and synthesis co	nditions for formation control loops involving	ng either LTI or LP	V agent models
	Students can explain the state space repre	sentation of spatially invariant distributed	systems that are o	discretized accord
	to an actuator/sensor array			
	They can explain (in outline) the extension	on of the bounded real lemma to such di	stributed systems	s and the associa
	synthesis conditions for distributed controll	ers		
Skills	 Students are capable of constructing LPV 	models of nonlinear plants and carry o	ut a mixed-sensit	ivity design of g
	scheduled controllers; they can do this usin			, , ,
	They are able to use standard software too		tasks	
	Students are able to design distributed fo	rmation controllers for groups of agents v	with either LTI or !	LPV dvnamics. us
	Matlab tools provided	alion controllers for groups or agents .	Their citation Err or i	
	Students are able to design distributed con	trollers for spatially interconnected system	us jusing the Matla	h MD-toolhov
	• Students are able to design distributed con	trollers for spatially interconnected system	s, using the Matia	ID MID-LOOIDOX
Personal Competence				
Social Competence	Students can work in small groups and arrive at jo	pint results.		
Autonomy	Students are able to find required information in	sources provided (lecture notes, literature,	software docume	ntation) and use i
,	solve given problems.	,		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
Workload in Hours	Independent Study Time 124, Study Time in Lectu	ure 56		
Credit points				
Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Control and		oulsory	
Assignment for the Following Curricula		aft Systems: Elective Compulsory		
•	Aircraft Systems Engineering: Specialisation Aircra			
•	Aircraft Systems Engineering: Specialisation Avior			
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec	ialisation II. Mechatronics: Elective Compul	sory	
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect	ialisation II. Mechatronics: Elective Compul tive Compulsory	sory	
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a	ialisation II. Mechatronics: Elective Compul tive Compulsory and Robotics: Elective Compulsory	sory	
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a	ialisation II. Mechatronics: Elective Compul tive Compulsory and Robotics: Elective Compulsory and Endoprostheses: Elective Compulsory		
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a Biomedical Engineering: Specialisation Medical Te	ialisation II. Mechatronics: Elective Compul tive Compulsory and Robotics: Elective Compulsory and Endoprostheses: Elective Compulsory echnology and Control Theory: Elective Con	npulsory	
•	Aircraft Systems Engineering: Specialisation Avior International Management and Engineering: Spec Mechatronics: Specialisation System Design: Elect Mechatronics: Specialisation Intelligent Systems a Biomedical Engineering: Specialisation Implants a	ialisation II. Mechatronics: Elective Compul tive Compulsory and Robotics: Elective Compulsory and Endoprostheses: Elective Compulsory echnology and Control Theory: Elective Con ent and Business Administration: Elective C	npulsory compulsory	

Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0661: Advanced Top	oics in Control				
Тур	Lecture				
Hrs/wk					
СР					
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28				
Lecturer	of. 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 Top	ourse L0662: Advanced Topics in Control		
Тур	Recitation Section (small)		
Hrs/wk	2		
СР	3		
Workload in Hours	dependent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	WiSe		
Content	See interlocking course		
Literature	See interlocking course		

Specialization Medical Technology and Control Theory

Module M0623: Intelli	igent Systems	in Medicine				
Courses						
Title			7	Гур	Hrs/wk	СР
Intelligent Systems in Medicine (LO	331)			Lecture	2	3
Intelligent Systems in Medicine (L0	334)		F	Project Seminar	2	2
Intelligent Systems in Medicine (L0	333)		F	Recitation Section (small)	1	1
Module Responsible	Prof. Alexander Schla	efer				
Admission Requirements	None					
Recommended Previous	• principles of m	ath (algebra, analysis/ca	lculus)			
Knowledge	 principles of st 		iculus)			
		rogramming, Java/C++ ar	nd R/Matlab			
	advanced prog		ra ry racias			
Educational Objectives	After taking part succ	essfully, students have r	eached the following	g learning results		
Professional Competence						
Knowledge				nning and decision suppo		
				classification and their res		
		•		for representing medical	-	
			allenges due to the	clinical nature of the data	a and its acquisitio	n and due to privacy
	and safety requireme	ents.				
Skills	The students can giv	e reasons for selecting a	and adapting method	ds for classification, regre	ession, and predict	ion. They can assess
	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						11
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 T	ime 110, Study Time in L	ecture 70			
Credit points	6	· · · · · · · · · · · · · · · · · · ·				
Course achievement	Compulsory Bonus	Form	Description			
	Yes 10 %	Written elaboration				
	Yes 10 %	Presentation				
Examination	Written exam					
Examination duration and	90 minutes					
scale						
Assignment for the	Computer Science: S	pecialisation Intelligence	Engineering: Elective	e Compulsory		
Following Curricula	,	g: Specialisation Medical ⁻				
	*			ngineering and Robotics:	Elective Compulsor	ТУ
		lisation Intelligent System				
	_	•	-	nerative Medicine: Elective	e Compulsory	
	_	ng: Specialisation Implan				
	_	•		ontrol Theory: Elective Co		
	-			Administration: Elective		
		3 3	,	urse: Elective Compulsory		
	rneoretical Mechanic	aı Engineering: Specialisa	ation Bio- and Medica	al Technology: Elective Co	ompulsory	

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

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

ourses				
tle		Тур	Hrs/wk	СР
elligent Autonomous Agents and	d Cognitive Robotics (L0341)	Lecture	2	4
elligent Autonomous Agents and		Recitation Section (small)	2	2
Module Responsible	Rainer Marrone			
Admission Requirements	None			
Recommended Previous	Vectors, matrices, Calculus			
Knowledge				
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence				
	(goals, utilities, environments). They can decan be discussed in terms of decision proble world scenarios, students can summarize he formalism in static and dynamic settings. It settings, with and with complete access to solving (partially observable) Markov decisions Students can identify techniques for simult desired states. Students can explain coording of equilibria, social choice functions, voting processed states and select an appropriate agent a students can derive decision trees and applinetworks/dynamic Bayesian networks and different sampling techniques for simplified best action or policies for concrete settings.	define intelligence in terms of rational behavior, scribe the main features of environments. The notlems and algorithms for solving these problems, ow Bayesian networks can be employed as a kno n addition, students can define decision making to the state of the environment. In this context, so ion problems, and they can recall techniques for taneous localization and mapping, and can explanation problems and decision making in a multi-approtocol, and mechanism design techniques. Carchitecture for concrete agent application scenarily basic optimization techniques. For those application apply bayesian reasoning for simple queries. I agent scenarios. For simple and complex decision making students will apply different votir decision making students will apply different votir	otion of adversariation of adv	al agent cooperate uncertainty in restation and reason mple and sequencribe techniques value of informatiniques for achievem of different typed agent applicated also create Bayes on name and applicts can compute g different equilibit
Personal Competence				
•				
Social Competence	Students are able to discuss their solutions t	to problems with others. They communicate in Eng	glish	
		to problems with others. They communicate in Enganding of complex concepts by solving varaints of		ns
	Students are able of checking their understa	anding of complex concepts by solving varaints of		ns
Autonomy	Students are able of checking their understa Independent Study Time 124, Study Time in	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours	Students are able of checking their understa Independent Study Time 124, Study Time in 6	anding of complex concepts by solving varaints of		าร
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understa Independent Study Time 124, Study Time in 6	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes	anding of complex concepts by solving varaints of		ns
Autonomy Workload in Hours Credit points Course achievement Examination Examination and	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes	anding of complex concepts by solving varaints of		ns
Workload in Hours Credit points Course achievement Examination Examination and scale	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	anding of complex concepts by solving varaints of	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cot Biomedical Engineering: Specialisation Artifice	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Compulsory	concrete problen	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Students are able of checking their understal Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Cott Biomedical Engineering: Specialisation Artific Biomedical Engineering: Specialisation Impla	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory	concrete problem	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Composition Artific Biomedical Engineering: Specialisation Impla Biomedical Engineering: Specialisation Medical Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Specialisation Engineering: Sp	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory cal Technology and Control Theory: Elective Compulsory	e Compulsory Compulsory	ns
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in 6 None Written exam 90 minutes Computer Science: Specialisation Intelligence International Management and Engineering: Mechatronics: Technical Complementary Course Biomedical Engineering: Specialisation Implates Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Managements	te Engineering: Elective Compulsory Specialisation II. Information Technology: Elective urse: Elective Compulsory cial Organs and Regenerative Medicine: Elective Cants and Endoprostheses: Elective Compulsory	e Compulsory Compulsory	ns

_	tonomous Agents and Cognitive Robotics Lecture
	2
	4
	Independent Study Time 92, Study Time in Lecture 28
Cycle	
Content	Wide
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-cast 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, Markot 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 Theoren Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwait Theorem
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, Cambridg University Press, 2009

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

Module M1230: Selec	ted Topics of Biomedical Engineering	յ - Option A (6 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1663)		Seminar	2	3
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)		Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)		Recitation Section (small)	2	2
Development and Regulatory Appro	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	6			
Assignment for the	Biomedical Engineering: Specialisation Implants and E	Endoprostheses: Elective Compulsory		
Following Curricula	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
-	Biomedical Engineering: Specialisation Management a	•		
	Biomedical Engineering: Specialisation Artificial Organ		. ,	

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

Тур	Lecture
Hrs/wk	3
СР	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and	30 min
scale	
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well a Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagatic and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - 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
154	7-inko Drugguia "Hochfreguan-tochnik 1" Coringer (1000)
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)
	- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)
	- D. M. Pozar, "Microwave Engineering", Wiley (2011)
	V. Hussey K. Baula Warterger Francisch Brankland Willey (2000)
	- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)
	- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)

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

Course L1588: Development	Course L1588: Development and Regulatory Approval of 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	90 Minuten	
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 L1500, Forestimontal	Mathada facilità Characteristica of Matadala
•	Methods for the Characterization of Materials
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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).

G	the data was a fine to
Course L1583: Numerical Me	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	 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 Biom	Course L1890: Seminar Biomedical Engineering		
Тур	Seminar		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Examination Form	Referat		
Examination duration and	schriftliche ausarbeitung und Vortrag (20 min)		
scale			
Lecturer	Prof. Michael Morlock		
Language	DE		
Cycle	WiSe		
Content			
Literature	Keine		

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	90 Minuten
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

Tom	Lactura	
	Lecture	
	2	
	4	
	Independent Study Time 92, Study Time in Lecture 28	
Examination Form	Klausur	
xamination duration and		
scale		
Lecturer	Prof. Michael Schlüter	
Language	DE	
Cycle	WiSe	
Content		
	Differential equations for momentum-, heat and mass transfer	
	Examples for simplifications of the Navier-Stokes Equations	
	Unsteady momentum transfer	
	Free shear layer, turbulence and free jets Flavoration of the Property Flavoration	
	Flow around particles - Solids Process Engineering	
	Coupling of momentum and heat transfer - Thermal Process Engineering Plantage Pinanage Foreign (1997) Plantage Pinanage Pinanage Foreign (1997) Plantage Pinanage	
	Rheology - Bioprocess Engineering Continue (Continue Continue Continu	
	Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering	
	Flow threw porous structures - heterogeneous catalysis	
	Pumps and turbines - Energy- and Environmental Process Engineering	
	Wind- and Wave-Turbines - Renewable Energy	
	Introduction into Computational Fluid Dynamics	
Literature		
	1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.	
	2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.	
	3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.	
	 Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelber 2006. 	
	5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.	
	 Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömunge Springer Verlag, Berlin, Heidelberg, New York, 2006. 	
	7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GW	
	Fachverlage GmbH, Wiesbaden, 2008.	
	8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007	
	9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubne	
	GWV Fachverlage GmbH, Wiesbaden, 2009.	
	10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.	
	11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Spring	
	Verlag, Berlin, Heidelberg, 2008.	
	12. Schlichting, H.: Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.	

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

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

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

Module M0746: Micro	system Engineering			
Courses				
Title		Тур	Hrs/wk	СР
Microsystem Engineering (L0680)		Lecture	2	4
Microsystem Engineering (L0682)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Manfred Kasper			
Admission Requirements	None			
Recommended Previous	Basic courses in physics, mathematics and electric engineering			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the follow	ing learning results		
Professional Competence				
Knowledge	The students know about the most important technologies ar actuators.	nd materials of MEMS as well as	their application	ons in sensors and
Skills	Students are able to analyze and describe the functional be microsystems.	ehaviour of MEMS components	and to evaluat	te the potential of
Personal Competence				
Social Competence	Students are able to solve specific problems alone or in a group	and to present the results accord	lingly.	
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with			
Autonomy	other fields.	inzed interactive and to integrate a	and associate t	ilis kilowieuge with
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	CompulsoryBonusFormDescriptionNo10 %Presentation			
Examination	Written exam			
Examination duration and scale	2h			
Assignment for the	Electrical Engineering: Core Qualification: Compulsory			
Following Curricula	Computational Science and Engineering: Specialisation Systems	Engineering and Robotics: Electi	ve Compulsory	
	International Management and Engineering: Specialisation II. Ele	ectrical Engineering: Elective Com	pulsory	
	International Management and Engineering: Specialisation II. Me			
	International Management and Engineering: Specialisation II. Ele		pulsory	
	International Management and Engineering: Specialisation II. Me			
	Mechanical Engineering and Management: Specialisation Mechanical			
	Mechanical Engineering and Management: Specialisation Mechanical Engineering and Management Engineerin			
	Mechatronics: Specialisation System Design: Elective Compulso			
	Mechatronics: Specialisation System Design: Elective Compulso	•		
	Biomedical Engineering: Specialisation Artificial Organs and Reg		pulsory	
	Biomedical Engineering: Specialisation Implants and Endoprosth Biomedical Engineering: Specialisation Medical Technology and		onv	
	Biomedical Engineering: Specialisation Medical Technology and Biomedical Engineering: Specialisation Management and Busine		-	
	Microelectronics and Microsystems: Core Qualification: Elective	·	uisUi y	
	Theoretical Mechanical Engineering: Technical Complementary			
	Theoretical Mechanical Engineering: Specialisation Bio- and Mec	• •	sorv	
	Theoretical Mechanical Engineering: Specialisation Bio- and Mec			

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

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

Module M0751: Vibra	tion Theory			
Courses				
Title		Тур	Hrs/wk	СР
Vibration Theory (L0701)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous	Calculus			
Knowledge	Linear Algebra			
	Engineering Mechanics			
•	After taking part successfully, students have reached	the following learning results		
Professional Competence				
	Students are able to denote terms and concepts of Vibration Theory and develop them further.			
	Students are able to denote methods of Vibration The	ory and develop them further.		
Personal Competence				
	Students can reach working results also in groups.			
Autonomy	Students are able to approach individually research tasks in Vibration Theory.			
Workload in Hours		66		
Credit points				
Course achievement				
Examination duration and	2 Hours			
scale				
Assignment for the				
Following Curricula	International Management and Engineering: Specialis	·	-	
	Mechanical Engineering and Management: Specialisat	ion Mechatronics: Elective Compulso	ry	
	Mechatronics: Core Qualification: Compulsory	as and Degenerative Medicin Elti-	o Campulaan	
	Biomedical Engineering: Specialisation Artificial Organ Biomedical Engineering: Specialisation Implants and E	•	e compulsory	
	Biomedical Engineering: Specialisation Implants and to Biomedical Engineering: Specialisation Medical Techn		mnulsory	
	Biomedical Engineering: Specialisation Management	•		
	Product Development, Materials and Production: Core			
	Naval Architecture and Ocean Engineering: Core Qual			
	Theoretical Mechanical Engineering: Core Qualificatio			
	Theoretical Mechanical Engineering: Technical Compl	·	У	

Course L0701: Vibration The	ourse 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				
Courses				
Fitle Microsystems Technology (L0724)		Typ Lecture	Hrs/wk 2	CP 4
Microsystems Technology (L0725)		Project-/problem-based Learning	2	2
Module Responsible	Prof. Hoc Khiem Trieu			
Admission Requirements	None			
Recommended Previous	Basics in physics, chemistry, mechanics and semiconducto	r technology		
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fo	ollowing learning results		
Professional Competence				
Knowledge	Students are able			
	to present and to explain current fabrication techni	ques for microstructures and especia	illy methods fo	r the fabrication
	microsensors and microactuators, as well as the integration	n thereof in more complex systems		
	to explain in details operation principles of microsenso	rs and microactuators and		
	to discuss the potential and limitation of microsystems	in application.		
Skills	Students are capable			
	to analyze the feasibility of microsystems,			
	to analyze the leasibility of filicrosystems,			
	to develop process flows for the fabrication of microstr	uctures and		
	to apply them.			
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab experir	nents in team work as well as to prese	ent and discuss	the results in fro
	of audience.			
Autonomy	None			
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	Compulsory Bonus Form Description			
	-	enden führen in Kleingruppen ein La	•	
	·	iert und diskutiert die Theorie sowie (n gesamten Kurs.	ale Ergebniise i	nrer Labortatigke
	vor den	i gesainten kuls.		
Examination	Oral exam			
Examination duration and	30 min			
scale	Flanking Franker Consideration No. 100 Page 1	Minney Tanker to Florida C		
Assignment for the		,	mpuisory	
Following Curricula	Electrical Engineering: Specialisation Medical Technology: Computational Science and Engineering: Specialisation Sys		ive Compulsory	
	International Management and Engineering: Specialisation		20111pui301 y	
	Biomedical Engineering: Specialisation Artificial Organs and		npulsory	
	Biomedical Engineering: Specialisation Implants and Endop		•	
	Biomedical Engineering: Specialisation Medical Technology	and Control Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Management and B	usiness Administration: Elective Comp	ulsory	
	Microelectronics and Microsystems: Core Qualification: Elec	tive Compulsory		

Course L0724: Microsystems	Technology
Тур	Lecture
Hrs/wk	2
СР	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	 Introduction (historical view, scientific and economic relevance, scaling laws) Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting) Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; 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, SUB, 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) Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer) Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip) Micro Actuators
	 DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics) MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration) Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship) System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID)
Literature	
	N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009
	T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010
	G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008

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

ourses				
tle		Тур	Hrs/wk	СР
chnology Management (L0849)		Project-/problem-based Learning	3	3
chnology Management Seminar	(L0850)	Project-/problem-based Learning	2	3
Module Responsible	Prof. Cornelius Herstatt			
Admission Requirements	None			
Recommended Previous	Bachelor knowledge in business management			
Knowledge				
Educational Objectives	After taking part successfully, students have reached the fol	llowing learning results		
Professional Competence				
Knowledge	Students will gain deep insights into:			
	International R&D-Management			
	Technology Timing Strategies			
	 Technology Strategies and Lifecycle Management 	ent (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	The course aims to:			
	Develop an understanding of the importance of Techr	pology Management - on a national a	c wall ac intari	national level
	Equip students with an understanding of import			
	organizational and process-related aspects)	tant crements of recimency, rial	agement (se	acegie, operacio
	Foster a strategic orientation to problem-solving with	nin the innovation process as well as	s Technology N	Management and
	importance for corporate strategy	, , , , , , , , , , , , , , , , , , , ,	,	
	 Clarify activities of Technology Management (e.g. tec 	hnology sourcing, maintenance and e	exploitation)	
	 Strengthen essential communication skills and a ba 			and financial iss
	concerning Technology-, Innovation- and R&D-manag	ement. Further topics to be discussed	d include:	
	Basic concepts, models and tools, relevant to the man	nagement of technology, R&D and in	novation	
	 Innovation as a process (steps, activities and results) 			
Personal Competence				
Social Competence				
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Interact within a team			
	 Raise awareness for globabl issues 			
Autonomy				
riaconomy	 Gain access to knowledge sources 			
	 Discuss recent research debates in the context of Technology 	chnology and Innovation Managemen	t	
	 Develop presentation skills 			
	 Discussion of international cases in R&D-Managemen 	t		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 minutes			
scale				
Assignment for the	Global Innovation Management: Core Qualification: Compuls	sory		
Following Curricula	Global Technology and Innovation Management & Entreprer		ory	
3	International Management and Engineering: Specialisation I.	·	-	
	Mechanical Engineering and Management: Specialisation Ma			
	Biomedical Engineering: Specialisation Artificial Organs and		npulsory	
	Biomedical Engineering: Specialisation Implants and Endopr		-	
	Biomedical Engineering: Specialisation Medical Technology		sory	
	Biomedical Engineering: Specialisation Management and Bu			

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

Module M0846: Contr	ol Systems Theory and Design			
Courses				
Title		Тур	Hrs/wk	СР
Control Systems Theory and Design		Lecture	2	4
Control Systems Theory and Design		Recitation Section (small)	2	2
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Introduction to Control Systems			
	After taking part successfully, students have re	eached the following learning results		
Professional Competence	Their taking pair successiony, stadents have re	defice the following fearning results		
Knowledge				
	response to initial states or external exc	nic systems are represented as state space itation as trajectories in state space controllability and observability, and their r		
	estimation, respectively			
	They can explain the significance of a m	inimal realisation		
		eedback and how it can be used to achieve t	racking and disturb	oance rejection
	They can extend all of the above to multi- They can explain the 7 transform and its			
	 They can explain the z-transform and its They can explain state space models an 	d transfer function models of discrete-time s	/stems	
	· · · · ·	ification of ARX models of dynamic systems,		ification problem can
	be solved by solving a normal equation			
	They can explain how a state space mod	del can be constructed from a discrete-time i	mpulse response	
Skills		n models into state space models and vice ve	rsa	
		rvability and construct minimal realisations	.50	
	They can design LQG controllers for mul			
	They can carry out a controller design	both in continuous-time and discrete-time do	main, and decide	which is appropriate
	for a given sampling rate			
		els and state space models of dynamic system		
	Simulink)	ng standard software tools (Matlab Control	looibox, System id	lentification looibox,
Personal Competence				
	Students can work in small groups on specific p	problems to arrive at joint solutions.		
Autonomy	Students can obtain information from provide when solving given problems.	ed sources (lecture notes, software docume	ntation, experimer	nt guides) and use it
	They can assess their knowledge in weekly on-	line tests and thereby control their learning p	progress.	
	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	120 min			
Scale	Computer Science: Specialization Laterline	Engineering, Elective Computers		
	Computer Science: Specialisation Intelligence E Electrical Engineering: Core Qualification: Com			
. onowing curricula	Energy Systems: Core Qualification: Elective Co			
	Aircraft Systems Engineering: Specialisation Ai			
	Aircraft Systems Engineering: Specialisation Av	· · ·	oulsory	
	Computational Science and Engineering: Speci	alisation II. Engineering Science: Elective Cor	npulsory	
	International Management and Engineering: Sp			
	International Management and Engineering: Sp.			
	Mechanical Engineering and Management: Spe Mechatronics: Core Qualification: Compulsory	cialisation Mechatronics: Elective Compulsor	y	
	Biomedical Engineering: Specialisation Artificia	I Organs and Regenerative Medicine: Elective	e Compulsorv	
	Biomedical Engineering: Specialisation Implant	•	, ,	
	Biomedical Engineering: Specialisation Medical		•	
	Biomedical Engineering: Specialisation Manage		Compulsory	
	Product Development, Materials and Production			
	Theoretical Mechanical Engineering: Core Qual	itication: Compulsory		

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

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

Module M0867: Produ	ıction Planning & Control an	d Digital Enterprise		
Courses				
Title		Тур	Hrs/wk	СР
The Digital Enterprise (L0932)		Lecture	2	2
Production Planning and Control (Li	0929)	Lecture	2	2
Production Planning and Control (Li	0930)	Recitation Section (small)	1	1
Exercise: The Digital Enterprise (L0	933)	Recitation Section (small)	1	1
Module Responsible	Prof. Hermann Lödding			
Admission Requirements	None			
Recommended Previous	Fundamentals of Production and Quality	Management		
Knowledge				
Educational Objectives	After taking part successfully, students h	ave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the contents of the	module in detail and take a critical position to them	١.	
Skills	Students are capable of choosing and applying models and methods from the module to industrial problems.			
Personal Competence	3	,, ,		
•	Students can develop joint solutions in mixed teams and present them to others.			
Autonomy	-			
Workload in Hours	Independent Study Time 96, Study Time	in Lecture 84		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	180 Minuten			
scale				
Assignment for the	International Management and Engineeri	ng: Specialisation II. Product Development and Product	luction: Elective Co	ompulsory
Following Curricula	Logistics, Infrastructure and Mobility: Spe	ecialisation Production and Logistics: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation A	rtificial Organs and Regenerative Medicine: Elective	Compulsory	
	Biomedical Engineering: Specialisation In	nplants and Endoprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation M	edical Technology and Control Theory: Elective Con	npulsory	
	Biomedical Engineering: Specialisation M	anagement and Business Administration: Compulso	ory	
	Product Development, Materials and Prod	duction: Specialisation Product Development: Electiv	ve Compulsory	
	Product Development, Materials and Prod	duction: Specialisation Production: Compulsory		
	Product Development, Materials and Prod	duction: Specialisation Materials: Elective Compulso	ry	
	Theoretical Mechanical Engineering: Spec	cialisation Product Development and Production: Ele	ective Compulsory	
	Theoretical Mechanical Engineering: Tech	nnical Complementary Course: Elective Compulsory		

Course L0932: The Digital Er	nterprise
	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

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

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

Module M0921: Electi	ronic Circuits for Medical Ap	plications		
Courses				
Fitle Electronic Circuits for Medical Appl	lications (L0696)	Typ Lecture	Hrs/wk 2	CP 3
Electronic Circuits for Medical Appl Electronic Circuits for Medical Appl		Recitation Section (small) Practical Course	1 1	2
Module Responsible		Tractical Course	1	1
Admission Requirements				
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students h	nave reached the following learning results		
Professional Competence				
Knowledge	Students can explain the basic fur Students are able to explain the b Students can exemplify the comm Students can describe the special Students can explain the functions Students are able to discuss the p	nctionality of the information transfer by the cent uild-up of an action potential and its propagation nunication between neurons and electronic device features of low-noise amplifiers for medical appli s of prostheses, e. g. an artificial hand otential and limitations of cochlea implants and a	along an axon es cations	
Skills	Students can calculate the time of the students can give scenarios for further students can develop the block develop the block develop the block develop the students.	dependent voltage behavior of an action potential rther improvement of low-noise and low-power singrams of prosthetic systems solocks of electronic systems for an articifial eye.		
Personal Competence Social Competence	Students are trained to solve proprofessional background. Students are able to recognize the	oblems in the field of medical electronics in te eir specific limitations, so that they can ask for as k in a clear manner and communicate their res	sistance to the right	time.
Autonomy	 Students are able to realistically judge the status of their knowledge and to define actions for improvements when necessary. Students can break down their work in appropriate work packages and schedule their work in a realistic way. Students can handle the complex data structures of bioelectrical experiments without needing support. Students are able to act in a responsible manner in all cases and situations of experimental work. 			
Workload in Hours	Independent Study Time 124, Study Tim	e in Lecture 56		
Credit points		Description		
Course achievement	Yes None Subject theore practical work No None Excercises			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the				
Following Curricula		dical Technology: Elective Compulsory rtificial Organs and Regenerative Medicine: Elect	ive Compulsory	
		rtificial Organs and Regenerative Medicine: Elect nplants and Endoprostheses: Elective Compulsor		
		ledical Technology and Control Theory: Compulso		
		lanagement and Business Administration: Electiv		
	Microelectronics and Microsystems: Spec	cialisation Microelectronics Complements: Electiv	e Compulsory	
	Theoretical Mechanical Engineering: Spe	cialisation Bio- and Medical Technology: Elective	Compulsory	
		hnical Complementary Course: Elective Compuls		
	Theoretical Mechanical Engineering: Spe	cialisation Bio- and Medical Technology: Elective	Compulsory	

Course L0696: Electronic Circ	cuits for Medical Applications
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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 Cir	cuits for Medical Applications
Тур	Practical Course
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	 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: Conti	nuum Mechanics			
Courses				
Title		Тур	Hrs/wk	СР
Continuum Mechanics (L1533)		Lecture	2	3
Continuum Mechanics Exercise (L1	534)	Recitation Section (small)	2	3
Module Responsible	Prof. Christian Cyron			
Admission Requirements	None			
Recommended Previous	Basics of linear continuum mechanics as taught, e.g.,	in the module Mechanics II (forces and	I moments, stres	ss, linear strain, free-
Knowledge	body principle, linear-elastic constitutive laws, strain er	nergy).		
Educational Objectives	After taking part successfully, students have reached to	ne following learning results		
Professional Competence				
Knowledge				
	The students can explain the fundamental concepts to	calculate the mechanical behavior of m	naterials.	
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.		pplied contexts as in	
Personal Competence				
Social Competence	The students are able to develop solutions, to present	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.		wn identify and solve	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56	j		
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	45 min			
scale				
Assignment for the	Materials Science: Specialisation Modeling: Elective Co	mpulsory		
Following Curricula	Mechanical Engineering and Management: Specialisation	on Materials: Elective Compulsory		
	Mechatronics: Technical Complementary Course: Electi	ve Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs	and Regenerative Medicine: Elective C	Compulsory	
	Biomedical Engineering: Specialisation Implants and Er	doprostheses: Elective Compulsory		
	Biomedical Engineering: Specialisation Medical Techno	logy and Control Theory: Elective Comp	oulsory	
	Biomedical Engineering: Specialisation Management ar		mpulsory	
	Product Development, Materials and Production: Core (
	Theoretical Mechanical Engineering: Technical Complete			
	Theoretical Mechanical Engineering: Core Qualification	Elective Compulsory		

Course L1533: Continuum Me	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: Continuum Mechanics Exercise	
Тур	Recitation Section (small)
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	 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: Mate	rial Modeling
Courses	
Title	Typ Hrs/wk CP
Material Modeling (L1535)	Lecture 2 3
Material Modeling (L1536)	Recitation Section (small) 2 3
Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous	Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (for
Knowledge	and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can explain the fundamentals of multidimensional consitutive material laws
Skills	The students can implement their own material laws in finite element codes. In particular, the students can apply their knowled
	to various problems of material science and evaluate the corresponding material models.
Personal Competence	
Social Competence	The students are able to develop solutions, to present them to specialists and to develop ideas further.
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and so
	problems in the area of materials modeling and acquire the knowledge required to this end.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	
Course achievement	
Examination	
Examination duration and	
scale	
Assignment for the	
Following Curricula	
3	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory
	Product Development, Materials and Production: Core Qualification: Elective Compulsory
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

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

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

Module M1199: Adva	nced Functional Materials	
Courses		
Title	Typ Hrs/wk CP	
Advanced Functional Materials (L16	Seminar 2 6	
Module Responsible	Prof. Patrick Huber	
Admission Requirements	None	
Recommended Previous	Basic knowledge in Materials Science, e.g. Materials Science I/II	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particula	
	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 or	
	modern materials science, which enables them to select optimum materials combinations depending on the technical	
	applications.	
Personal Competence		
_	The students are able to present solutions to specialists and to develop ideas further.	
Social competence	The statents are use to present solutions to specialists and to develop facus farther.	
Autonomy	The students are able to	
	assess their own strengths and weaknesses.	
	gather new necessary expertise by their own.	
Workload in Hours		
Credit points Course achievement		
Examination		
Examination duration and		
scale	30 (1)(1)	
Assignment for the	Materials Science: Core Qualification: Compulsory	
Following Curricula	Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory	
	Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory	
	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory	
	Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory	
	Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory	
	Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory	
	Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory	

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

Module M1241: Selec	ted Topics of Biomedical Engineering	J - Option B (12 LP)		
Courses				
Title		Тур	Hrs/wk	СР
Nature's Hierarchical Materials (L1	563)	Seminar	2	3
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Anten	nas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2
Development and Regulatory Appr	oval of Implants (L1588)	Lecture	2	3
Experimental Methods for the Char	acterization of Materials (L1580)	Lecture	2	3
Numerical Methods in Biomechanic	s (L1583)	Seminar	2	3
Seminar Biomedical Engineering (L	1890)	Seminar	2	3
Six Sigma (L1130)		Lecture	2	3
Fluid Mechanics II (L0001)		Lecture	2	4
System Simulation (L1820)		Lecture	2	2
System Simulation (L1821)		Recitation Section (large)	1	2
Ceramics Technology (L0379)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous				
Knowledge				
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
Workload in Hours	Depends on choice of courses			
Credit points	12			
Assignment for the	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: Elective	Compulsory	
Following Curricula	Biomedical Engineering: Specialisation Implants and E	indoprostheses: Elective Compulsory		
_	Biomedical Engineering: Specialisation Medical Techn	ology and Control Theory: Elective Com	pulsory	
	3 11 3 1, 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1	J,,,		

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

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

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

Course L1588: Development and Regulatory Approval of 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	90 Minuten	
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	90 min
scale	
Lecturer	Prof. Patrick Huber
Language	DE
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 Me	
Тур	Seminar
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and	90 Minuten
scale	
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	SoSe
Content	 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	schriftliche ausarbeitung und Vortrag (20 min)
scale	
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	90 Minuten	
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	

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

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

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

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

Module M1279: MED I	II: Introduction to Biochemistry and Molecular Biology
Courses	
Title	Typ Hrs/wk CP
Introduction to Biochemistry and M	lolecular Biology (L0386) Lecture 2 3
Module Responsible	Prof. Hans-Jürgen Kreienkamp
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe basic biomolecules;
	explain how genetic information is coded in the DNA;
	explain the connection between DNA and proteins;
CI 'II.	
SKIIIS	The students can
	recognize the importance of molecular parameters for the course of a disease;
	describe selected molecular-diagnostic procedures;
	explain the relevance of these procedures for some diseases
Personal 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.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination	Written exam
Examination duration and	60 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechani
	Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechani
	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
	- Communication operational in Engineering Selective Company

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

Module M1333: BIO I:	Implants and Fracture Healing		
Courses			
Title	Typ Hrs/wk CP		
Implants and Fracture Healing (L03	376) Lecture 2 3		
Module Responsible	Prof. Michael Morlock		
Admission Requirements	None		
Recommended Previous	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".		
Knowledge			
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence			
Knowledge			
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.		
Skills	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.		
Personal Competence			
Social Competence	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
Autonomy	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Credit points	3		
Course achievement	None		
Examination	Written exam		
Examination duration and	90 min		
scale			
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics		
Following Curricula	Compulsory		
	General Engineering Science (German program, 7 semester): 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 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		
	Orientierungsstudium: Core Qualification: Elective Compulsory		
	Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

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

Module M1334: BIO II	: Biomaterials			
Courses				
Title		Тур	Hrs/wk	СР
Biomaterials (L0593)		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical techniques	s is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reached t	the following learning results		
Professional Competence				
Knowledge	The students can describe the materials of the human	body and the materials being us	sed in medical engineerir	ng, and their fields of
	use.			
Chille	The students can explain the advantages and disadva	atagas of different kinds of biom	vatarials	
SKIIIS	The students can explain the advantages and disadvan	itages of different kinds of bloth	iateriais.	
Personal Competence				
Social Competence	The students are able to discuss issues related to mat	erials being present or being us	sed for replacements with	student mates and
	the teachers.			
Autonomy	The students are able to acquire information on their o	own. They can also judge the info	ormation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28			
Credit points	3			
Course achievement	None			
Examination	Written exam			
Examination duration and	90 min			
scale				
Assignment for the	International Management and Engineering: Specialisa	tion II. Process Engineering and	Biotechnology: Elective (Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid Mat	erials: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organ	s and Regenerative Medicine: El	ective Compulsory	
	Biomedical Engineering: Specialisation Implants and E			
	Biomedical Engineering: Specialisation Medical Techno	• •		
	Biomedical Engineering: Specialisation Management a			
	Theoretical Mechanical Engineering: Technical Comple			
	Theoretical Mechanical Engineering: Specialisation Bio	- and Medical Technology: Electi	ive Compulsory	

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

Module M0808: Finite		<u></u>
Courses		
Title	Typ Hrs/wk	СР
Finite Element Methods (L0291)	Lecture 2	3
Finite Element Methods (L0804)	Recitation Section (large) 2	3
Module Responsible		
Admission Requirements	s None Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)	
	Mathematics I, II, III (in particular differential equations)	
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	e The students possess an in-depth knowledge regarding the derivation of the finite element method and overview of the theoretical and methodical basis of the method.	d are able to give
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembl system matrices, and solving the resulting system of equations.	ing the correspond
Personal Competence Social Competence	e Students can work in small groups on specific problems to arrive at joint solutions.	
Autonomy	The students are able to independently solve challenging computational problems and develop own fir Problems can be identified and the results are critically scrutinized.	nite element routir
Autonomy Workload in Hours	Problems can be identified and the results are critically scrutinized.	nite element routin
	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56	nite element routin
Workload in Hours	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 6	nite element routir
Workload in Hours Credit points	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 6	nite element routir
Workload in Hours Credit points	Problems can be identified and the results are critically scrutinized. s Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm	nite element routir
Workload in Hours Credit points Course achievement	Problems can be identified and the results are critically scrutinized. 5 Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm 1 Written exam	nite element routir
Workload in Hours Credit points Course achievement Examination	Problems can be identified and the results are critically scrutinized. 5 Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm 1 Written exam 1 120 min	nite element routin
Workload in Hours Credit points Course achievement Examination Examination duration and scale	Problems can be identified and the results are critically scrutinized. 5 Independent Study Time 124, Study Time in Lecture 56 6 Compulsory Bonus Form Description No 20 % Midterm 1 Written exam 1 120 min	nite element routin
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Compulsory Bonus Form Description No 20 % Midterm Written exam 1 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory	nite element routin
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Compulsory Bonus Form Description No 20 % Midterm Written exam 1 120 min Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory	nite element routin
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, Study Time in Lecture 56 Compulsory Bonus Form Description No 20 % Midterm Written exam Indication Compulsory Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory	nite element routin
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, St	nite element routin
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Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, Study Time in Lecture 56 Compulsory Bonus Form Description No 20 % Midterm Written exam Industry Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory	
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, St	Compulsory
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, St	Compulsory
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Compulsory Bonus Form Description No 20 % Midterm Written exam Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management and Engineering: Specialisation II. Product Development and Production: Elective International Management Interna	Compulsory
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Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, Study Time 124 Independent Study Time 124, Study Time 124 Independent Study Time	Compulsory
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Problems can be identified and the results are critically scrutinized. Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, Study Time 124, Study Time 124 Independent Study Time 124, Study Time 124 Independent Study Time 124, Study Time 124 Independent Stu	Compulsory
Workload in Hours Credit points Course achievement Examination Examination duration and scale Assignment for the	Independent Study Time 124, Study Time in Lecture 56 Independent Study Time 124, Study Time 124 Independent Study Time 124, Study Time 124 Independent Study Time	Compulsory

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

Course L0804: Finite Elemen	ourse L0804: Finite Element Methods		
Тур	Recitation Section (large)		
Hrs/wk	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: Polyn				
Courses				
Title		Тур	Hrs/wk	СР
Structure and Properties of Polymers (L0389)		Lecture	2	3
Processing and design with polyme		Lecture	2	3
Module Responsible	Dr. Hans Wittich			
Admission Requirements	None			
Recommended Previous	Basics: chemistry / physics / material scie	nce		
Knowledge				
Educational Objectives	After taking part successfully, students ha	ave reached the following learning results		
Professional Competence	Charles and a second along the second al		!_	
Knowledge	Students can use the knowledge of plastic	cs and define the necessary testing and analy	/SIS.	
	They can explain the complex relationship	os structure-property relationship and		
	the interactions of chemical structure of t	he polymers, including to explain neighboring	n contexts (e.g. sustaina	hility environment
	protection).	ne polymers, melading to explain heighboring	g contexts (e.g. sustaine	iomey, environment
	p			
Skills	Students are capable of			
	- using standardized calculation method	ds in a given context to mechanical prope	erties (modulus, streng	th) to calculate a
	evaluate the different materials.			
	- selecting appropriate solutions for mecr	nanical recycling problems and sizing exampl	e stiπness, corrosion res	sistance.
Personal Competence				
Social Competence	Students can			
	arrive at funded work results in betarage	onius groups and document them		
	- arrive at funded work results in heterogenius groups and document them.- provide appropriate feedback and handle feedback on their own performance constructively.			
Autonomy	Students are able to			
	- assess their own strengths and weaknes	ses.		
	- assess their own state of learning in spe	cific terms and to define further work steps o	n this basis.	
	- assess possible consequences of their pr	rofessional activity.		
		2		
Workload in Hours	Independent Study Time 124, Study Time	in Lecture 56		
Credit points				
Course achievement				
	Written exam			
Examination duration and	180 min			
scale	Matariala Caianas Caraisliantian Francisco	in a Matariala Elastina Carandana		
Assignment for the	Materials Science: Specialisation Engineer			
Following Curricula	Biomedical Engineering: Specialisation Im	tificial Organs and Regenerative Medicine: El	ective Compulsory	
	3 1	anagement and Business Administration: Elec	. ,	
		edical Technology and Control Theory: Electiv		
	3 1	uction: Specialisation Production: Elective Co		
	· ·	uction: Specialisation Materials: Elective Com		
	Product Development, Materials and Prod	uction: Specialisation Product Development:	Elective Compulsory	
	Theoretical Mechanical Engineering: Tech	nical Complementary Course: Elective Comp	ulsory	
	Theoretical Mechanical Engineering: Spec	ialisation Materials Science: Elective Compuls	sory	

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

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

Module M0632: Rege	nerative Medicine			
Courses				
Title Regenerative Medicine (L0347)	porative Medicine (11664)	Typ Seminar Seminar	Hrs/wk 2 2	CP 3
Lecture Tissue Engineering - Reger		Seminar	Z	3
Module Responsible				
Admission Requirements Recommended Previous				
Knowledge	None			
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence	Their taking pare successionly, students have reder	ica the following learning results		
Knowledge				
	The students can outline the actual concepts udnerlying principles of the discussed topics.	of Tissue Engineering and regenera	ative medicine and ca	n explain the basi
	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 work together as a team with 2-4 students to solve given tasks and discuss their results in the plenary and defend them. Students are able to reflect their work orally and discuss it with other students and teachers.			
Autonomy	After completion of this module, participants vindependently including a presentation of the resu		problem in teams of a	approx. 2-4 person:
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points				
Course achievement		Description Ausarbeitung zu Ringvorlesung / pro	otocol for lecture series	
Examination Examination duration and scale	Presentation Oral presentation + discussion (30 min)			
Assignment for the Following Curricula	Biomedical Engineering: Specialisation Implants at Biomedical Engineering: Specialisation Artificial Or Biomedical Engineering: Specialisation Manageme	rgans and Regenerative Medicine: Co ent and Business Administration: Elect	mpulsory tive Compulsory	
	Biomedical Engineering: Specialisation Medical Te	chilology and control friedry: Elective	compuisory	

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

	ectromagnetics: Principles a				
Courses					
Title		Тур	Hrs/wk	СР	
Bioelectromagnetics: Principles and	· · · · · · · · · · · · · · · · · · ·	Lecture	3	5	
Bioelectromagnetics: Principles and	d Applications (L0373)	Recitation Section (small	1) 2	1	
Module Responsible	Prof. Christian Schuster				
Admission Requirements	None				
	Basic principles of physics				
Knowledge					
Educational Objectives	After taking part successfully students h	ave reached the following learning results			
Professional Competence	Arter taking part successiony, students in	ave reached the following learning results			
•	Students can explain the basic principles	, relationships, and methods of bioelectromagn	etics i.e. the quantific	cation and application	
	of electromagnetic fields in biological tie them corresponding to wavelength and	ssue. They can define and exemplify the most frequency of the fields. They can give an over fromagnetic fields in practical applications . The	important physical p verview over measure	phenomena and ord ement and numeric	
Skills	Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the mos important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice.				
Personal Competence Social Competence	Students are able to work together on s English (e.g. during small group exercise	subject related tasks in small groups. They are s).	able to present their	r results effectively	
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 Time	e in Lecture 70			
Credit points	6				
Course achievement	Compulsory Bonus Form	Description			
	Yes 10 % Presentation				
Examination	Oral exam				
Examination duration and	45 min				
scale					
Assignment for the	Electrical Engineering: Specialisation Med	dical Technology: Elective Compulsory			
Following Curricula		rowave Engineering, Optics, and Electromagnet	tic Compatibility: Elec	tive Compulsory	
•		ng: Specialisation II. Electrical Engineering: Elec		. ,	
		rtificial Organs and Regenerative Medicine: Elec			
		nplants and Endoprostheses: Elective Compulso			
		ledical Technology and Control Theory: Elective	-		
		lanagement and Business Administration: Elective			
	Theoretical Mechanical Engineering: Tecl	hnical Complementary Course: Elective Compul:	sory		

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

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

Module M0630: Robot	tics and Naviga	tion in Medicine				
Courses						
Title Robotics and Navigation in Medicine (L0335) Robotics and Navigation in Medicine (L0338) Robotics and Navigation in Medicine (L0336)		Typ Lecture Project Sen Recitation	ninar Section (small)	Hrs/wk 2 2 1	CP 3 2	
Module Responsible	1	efer				
Admission Requirements	None					
Recommended Previous Knowledge	 principles of pr 	 principles of math (algebra, analysis/calculus) principles of programming, e.g., in Java or C++ solid R or Matlab skills 				
Educational Objectives	After taking part succ	essfully, students have re	eached the following learning	results		
	The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typic systems regarding design and limitations. The students are able to design and evaluate navigation systems and robotic systems for medical applications.				s can assess typical	
	The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.					
Workload in Hours	Independent Study Ti	me 110, Study Time in Le	ecture 70			
Credit points	6					
Course achievement	Yes 10 %	Form Presentation Written elaboration	Description			
Examination	Written exam					
Examination duration and scale	90 minutes					
Assignment for the	Computer Science: Sp	ecialisation Intelligence I	Engineering: Elective Compul	sory		
	Mechatronics: Special Biomedical Engineerir Biomedical Engineerir Biomedical Engineerir Biomedical Engineerir Product Development Product Development	isation Intelligent Systemng: Specialisation Artificiang: Specialisation Implanting: Specialisation Medicaling: Specialisation Manage, Materials and Productio, Materials and Productio	secialisation II. Electrical Engi is and Robotics: Elective Com I Organs and Regenerative M is and Endoprostheses: Electi Technology and Control The ement and Business Administ in: Specialisation Product Dev in: Specialisation Production: in: Specialisation Materials: El	npulsory ledicine: Elective (ve Compulsory ory: Elective Com ration: Elective Co elopment: Elective Elective Compulso	Compulsory pulsory ompulsory e Compulsory ory	
	Theoretical Mechanica	al Engineering: Technical	Complementary Course: Election Bio- and Medical Techno	tive 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				
	notion 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	rrse L0338: Robotics and Navigation in Medicine			
Тур	Project Seminar			
Hrs/wk	2			
СР	2			
Workload in Hours	pendent 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	exander Schlaefer			
Language	EN			
Cycle	SoSe			
Content	e interlocking course			
Literature	See interlocking course			

Courses		icai recimology an	d Systems		
itle			Тур	Hrs/wk	СР
ntroduction into Medical Technolog	gy and Systems (L0342)		Lecture	2	3
ntroduction into Medical Technolog	gy and Systems (L0343)		Project Seminar	2	2
ntroduction into Medical Technolog	yy and Systems (L1876)		Recitation Section (large	e) 1	1
Module Responsible	Prof. Alexander Schlaefe	er			
Admission Requirements	None				
Recommended Previous	principles of math (alge	bra, analysis/calculus)			
Knowledge	principles of stochastic	S			
	principles of programmi	ing, R/Matlab			
Educational Objectives	After taking part succes	sfully, students have reache	ed the following learning results		
Professional Competence			<u> </u>		
Knowledge	The students can expl	ain principles of medical to	echnology, including imaging syste	ms, computer aided	surgery, and medica
	· ·		view of regulatory affairs and standa		
CI:II-	The shorteness are able to		diant dayina ia tha anatawa af alicina	Landinskinna	
SKIIIS	The students are able to	o evaluate systems and med	dical devices in the context of clinica	i applications.	
Personal Competence					
Social Competence	The students describe a	problem in medical techno	logy as a project, and define tasks th	nat are solved in a join	t effort.
Autonomy	The students can reflec	t their knowledge and docu	ıment the results of their work. The	y can present the res	ulte in an appropriat
Autonomy	manner.	it their knowledge and doct	intent the results of their work. The	y can present the res	uits iii aii appiopiiat
	mamier.				
Workload in Hours	Independent Study Time	e 110, Study Time in Lectur	e 70		
Credit points	6				
Course achievement			Description		
		Presentation			
Examination duration and	90 minutes				
-	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory				
Following Curricula				sory	
	Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory				
	·		•		
	Diomicalcal Engineering	. Specialisation Artificial Org			
		· Specialisation Implants and	d Endonrostheses: Flective Compuls		
	Biomedical Engineering	·	d Endoprostheses: Elective Compuls hnology and Control Theory: Elective	•	
	Biomedical Engineering Biomedical Engineering	: Specialisation Medical Tec	d Endoprostheses: Elective Compuls hnology and Control Theory: Elective It and Business Administration: Elect	e Compulsory	
Credit points Course achievement Examination	General Engineering Sci Computational Science Computational Science Computational Science Computational Science	Form Written elaboration Presentation Presentation ience (German program, 7 scialisation Computer and So Core Qualification: Elective (ience (English program, 7 sciand Engineering: Specialisa and Engineering: Specialisa and Engineering: Specialisa and Engineering: Specialisa	Description Description Description Demoster): Specialisation Biomedical ftware Engineering: Elective Compulsory Demoster): Specialisation Biomedical lition II. Mathematics & Engineering Stion Computer Science: Elective Contion Engineering Sciences: Elective Capans and Regenerative Medicine: Elective Medicine: E	Engineering: Compulso cience: Elective Comp npulsory Compulsory ctive Compulsory	pry

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

Course L0343: Introduction i	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 in	nto Medical Technology and Systems
Тур	Recitation Section (large)
Hrs/wk	1
СР	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems
	- computer aided surgery
	- medical sensor systems
	- medical information systems
	- regulatory affairs
	- standard in medical technology
	The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Wird in der Veranstaltung bekannt gegeben.

Module M0752: Nonlin	near Dynamics			
Courses				
Title		Тур	Hrs/wk	СР
Nonlinear Dynamics (L0702)		Integrated Lecture	4	6
Module Responsible	Prof. Norbert Hoffmann			
Admission Requirements	None			
Recommended Previous Knowledge	Calculus Linear Algebra Engineering Mechanics			
	• Engineering Mechanics			
Educational Objectives	After taking part successfully, students have reached the	e following learning results		
Professional Competence				
	Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts.			
	Students are able to apply existing methods and procesu	ires of Nonlinear Dynamics and to	o develop novel meth	ods and procedures.
Personal Competence				
· ·	Students can reach working results also in groups.			
Autonomy	Students are able to approach given research tasks indiv	idually and to identify and follow	up novel research ta	sks by themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56			
Credit points	6			
Course achievement	None			
Examination	Written exam			
Examination duration and	2 Hours			
scale				
Assignment for the	Aircraft Systems Engineering: Specialisation Aircraft Systems	ems: Elective Compulsory		
Following Curricula	International Management and Engineering: Specialisation	on II. Mechatronics: Elective Comp	oulsory	
	Mechanical Engineering and Management: Specialisation	Mechatronics: Elective Compuls	ory	
	Mechatronics: Specialisation System Design: Elective Co	mpulsory		
	Mechatronics: Specialisation Intelligent Systems and Rob	otics: Elective Compulsory		
	Biomedical Engineering: Specialisation Artificial Organs a	and Regenerative Medicine: Elect	ive Compulsory	
	Biomedical Engineering: Specialisation Implants and End	oprostheses: Elective Compulsor	у	
	Biomedical Engineering: Specialisation Medical Technolo			
	Biomedical Engineering: Specialisation Management and	Business Administration: Elective	e Compulsory	
	Product Development, Materials and Production: Core Qu	alification: Elective Compulsory		
	Theoretical Mechanical Engineering: Technical Complem	entary Course: Elective Compulso	ory	
	Theoretical Mechanical Engineering: Core Qualification: I	Elective Compulsory		

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

Courses				
Title		Тур	Hrs/wk	CP
Semiconductor Technology (L0722 Semiconductor Technology (L0723		Lecture Practical Course	4 2	4 2
Module Responsible		Tractical Coarse	2	2
Admission Requirements	None			
Recommended Previous		miconductor devices		
Knowledge	Sustees in projected, entermisery, material serience and se	conductor devices		
Educational Objectives	After taking part successfully, students have reached	the following learning results		
Professional Competence				
Knowledge				
	Students are able			
	Students are able			
	to describe and to explain current fabrication tec	hniques for Si and GaAs substrates,		
	to discuss in details the relevant fabrication	on processes, process flows and t	the impact thereof o	n the fabrication
	semiconductor devices and integrated circuits and			
	to present integrated process flows.			
	to present integrated process nows.			
Skills				
	Students are capable			
	to analyze the impact of process parameters on	the processing results,		
	to solect and to evaluate processes and			
	to select and to evaluate processes and			
	to develop process flows for the fabrication of se	miconductor devices.		
Personal Competence				
Social Competence				
	Students are able to prepare and perform their lab e	xperiments in team work as well as	to present and discus	s the results in fro
	of audience.			
A 4	M			
Autonomy Workload in Hours	None Independent Study Time 96, Study Time in Lecture 8	A		
Credit points		+		
Course achievement				
Examination				
Examination duration and				
scale				
Assignment for the	Electrical Engineering: Specialisation Nanoelectronics	,		
Following Curricula	Biomedical Engineering: Specialisation Artificial Orga Biomedical Engineering: Specialisation Implants and	3	' '	
	Biomedical Engineering: Specialisation Implants and Biomedical Engineering: Specialisation Medical Techn			
	Biomedical Engineering: Specialisation Medical Technical Engineering: Specialisation Management	• • • • • • • • • • • • • • • • • • • •		
	Microelectronics and Microsystems: Specialisation Mi			

0722: Semiconducto	
Тур	Lecture
Hrs/wk	4
CP Jorkload in Hours	4 Independent Study Time 64, Study Time in Lecture 56
	Prof. Hoc Khiem Trieu
Language	
Cycle	
Content	 Introduction (historical view and trends in microelectronics) Basics in material science (semiconductor, crystal, Miller indices, crystallographic defects) Crystal fabrication (crystal pulling for Si and 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, high order effects and process technology, ion implantation: theory, implantation profile, channeling, implantation dama annealing and equipment)
	 Oxidation (silicon dioxide: structure, electrical properties and oxide charges, thermal oxidation: reactions, kineti influences on growth rate, process technology and equipment, anodic oxidation, plasma oxidation, thermal oxidation GaAs) Deposition techniques (theory: nucleation, film growth and structure zone model, film growth process, reaction kineti temperature dependence and equipment; epitaxy: gas phase, liquid phase, molecular beam epitaxy; CVD techniques APCVD, LPCVD, deposition of metal silicide, PECVD and LECVD; basics of plasma, equipment, PVD techniques: high vacuit
	 Structuring techniques (subtractive methods, photolithography: resist properties, printing techniques: contact, proximi and projection printing, resolution limit, practical issues and equipment, additive methods: liftoff technique at electroplating, improving resolution: excimer laser light source, immersion lithography and phase shift lithography, electrobeam lithography, X-ray lithography, EUV lithography, ion beam lithography, wet chemical etching: isotropic ar anisotropic, corner undercutting, compensation masks and etch stop techniques; dry etching: plasma enhanced etchin backsputtering, ion milling, chemical dry etching, RIE, sidewall passivation) Process integration (CMOS process, bipolar process) Assembly and packaging technology (hierarchy of integration, packages, chip-on-board, chip assembly, electrical contact wire bonding, TAB and flip chip, wafer level package, 3D stacking)
Literature	S.K. Ghandi: VLSI Fabrication principles - Silicon and Gallium Arsenide, John Wiley & Sons
	S.M. Sze: Semiconductor Devices - Physics and Technology, John Wiley & Sons
	U. Hilleringmann: Silizium-Halbleitertechnologie, Teubner Verlag
	H. Beneking: Halbleitertechnologie - Eine Einführung in die Prozeßtechnik von Silizium und III-V-Verbindungen, Teubner Verlag
	K. Schade: Mikroelektroniktechnologie, Verlag Technik Berlin
	S. Campbell: The Science and Engineering of Microelectronic Fabrication, Oxford University Press
	P. van Zant: Microchip Fabrication - A Practical Guide to Semiconductor Processing, McGraw-Hill

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

Module M0835: Huma	noid Robotics			
Courses				
Title		Тур	Hrs/wk	СР
Humanoid Robotics (L0663)		Seminar	2	2
Module Responsible	Patrick Göttsch			
Admission Requirements	None			
Recommended Previous				
Knowledge	a Introduction to control systems			
	Introduction to control systemsControl theory and design			
	- Control tricory and design			
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	 Students can explain humanoid robots. 			
	Students learn to apply basic control co		botics.	
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	a presentation		
Personal Competence				
Social Competence				
Social competence	Students are capable of developing solutions in interdisciplinary teams and present them			
	 They are able to provide appropriate fe 	eedback and handle constructive criticism	of their own results	
Autonomy				
,	Students evaluate advantages and d	rawbacks of different forms of presenta	tion for specific tasks	and select the best
	solution			
	Students familiarize themselves with a		and follow presentation	ns of other students,
	such that a scientific discussion develo	ps		
Workload in Hours	Independent Study Time 32, Study Time in Le	ecture 28		
Credit points	2			
Course achievement	None			
Examination	Presentation			
Examination duration and	30 min			
scale				
Assignment for the	Mechatronics: Specialisation Intelligent Syste	• • •		
Following Curricula	Mechatronics: Specialisation System Design:		ather Committee	
	Biomedical Engineering: Specialisation Artifici	•		
	Biomedical Engineering: Specialisation Implar Biomedical Engineering: Specialisation Medical	·	•	
	Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Manac	•		
	Theoretical Mechanical Engineering: Technical			
	Theoretical Mechanical Engineering: Core Qua	·	··· <i>,</i>	

Course L0663: Humanoid Ro	ourse 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).		

Module M0838: Linea	r and Nonlinear System Identi	ifikation		
Courses				
Title		Тур	Hrs/wk	СР
Linear and Nonlinear System Identi	fication (L0660)	Lecture	2	3
Module Responsible	Prof. Herbert Werner			
Admission Requirements	None			
Recommended Previous Knowledge	Classical control (frequency response State space methods Discrete-time systems Linear algebra, singular value decom Basic knowledge about stochastic pro	position		
Educational Objectives	After taking part successfully, students have	e reached the following learning results		
Professional Competence Knowledge Skills Personal Competence Social Competence Autonomy	nonlinear model structures They can explain how multilayer perd They can explain how an approximat They can explain the idea of subspace Students are capable of applying the models for dynamic systems They are capable of implementing a management of the they are capable of applying subspaces. They are capable of applying subspaces they are capable of applying subspaces.	amework of the prediction error method and ceptron networks are used to model nonlineate predictive control scheme can be based on the identification and its relation to Kalman reache prediction error method to the experimental interpretation of the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation to Kalman reache prediction error method to the experimental identification and its relation error method to the experimental identification and its relation error method to the experimental identification and its relation error method to the experimental identification and its relation error method to the experimental identification and its relation error method to the experimental identification error method to the experimental identification and its relation error method to the experimental identification error method error metho	r dynamics neural network model alisation theory ental identification of n a neural network mo- ion of linear models for n Identification Toolbo	linear and nonlinear del r dynamic systems x)
	solve given problems.			
	Independent Study Time 62, Study Time in	Lecture 28		
Credit points				
Course achievement				
Examination				
Examination duration and scale	30 min			
Assignment for the	Electrical Engineering: Specialisation Contro	ol and Power Systems Engineering: Elective C	Compulsory	
Following Curricula	Mechatronics: Specialisation Intelligent Syst	tems and Robotics: Elective Compulsory		
	Mechatronics: Specialisation System Design			
		icial Organs and Regenerative Medicine: Elec		
		ants and Endoprostheses: Elective Compulso	•	
		ical Technology and Control Theory: Compuls	•	
		agement and Business Administration: Elective		
	Theoretical Mechanical Engineering: Technical Engineering: Core Q	cal Complementary Course: Elective Compul:	эот у	
	medical mechanical Engineering. Core Q	damication. Elective compulsory		

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

	nal and Robust Control			
Courses				
Fitle Optimal and Robust Control (L0658 Optimal and Robust Control (L0659		Typ Lecture Recitation Section (small)	Hrs/wk 2 2	CP 3 3
Module Responsible				
Admission Requirements				
Recommended Previous Knowledge	Classical control (frequency response, root l State space methods Linear algebra, singular value decompositio			
Educational Objectives	After taking part successfully, students have reach	ned the following learning results		
Professional Competence Knowledge	 Students can explain the significance of the They can explain the duality between optim They can explain how the H2 and H-infinity They can explain how an LQG design proble They can explain how model uncertainty ca They can explain how - based on the small an uncertain plant. They understand how analysis and synthesi Students are capable of designing and tunir They are capable of representing a H2 or H-software tools for solving it. They are capable of translating time and find sensitivity functions, and of carrying out a minimal transfer of the sensitivity functions. They are capable of formulating analysis and LMI-solvers for solving them. They can carry out all of the above using state 	nal state feedback and optimal state estimated norms are used to represent stability and purposes of an an be represented in a way that lends itself again theorem - a robust controller can gut as conditions on feedback loops can be represented for multivariable plant multiplications of a general problem in the form of a general	tion. herformance cons H2 design proble to robust control arantee stability esented as linear hodels. heralized plant, a loops into const h, and of designin equalities (LMI), a	m. ler design and performance i matrix inequalities and of using standa raints on closed-lo
Personal Competence				
•	Students can work in small groups on specific prob	olems to arrive at joint solutions		
Autonomy			software docume	ntation) and use it
Workload in Hours	Independent Study Time 124, Study Time in Lectu	re 56		
Credit points	6			
Course achievement	None			
Examination	Oral exam			
Examination duration and scale	30 min			
Assignment for the	Computer Science: Specialisation Intelligence Engi	neering: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation Control and F	Power Systems Engineering: Elective Comp	ulsory	
	Energy Systems: Core Qualification: Elective Comp	pulsory		
	Aircraft Systems Engineering: Specialisation Aircra	ft Systems: Elective Compulsory		
	Mechatronics: Specialisation Intelligent Systems at	• •		
	Mechatronics: Specialisation System Design: Elect		C	
	Biomedical Engineering: Specialisation Artificial Or	•	Compulsory	
	Biomedical Engineering: Specialisation Implants ar Biomedical Engineering: Specialisation Medical Te		nulsory	
	Biomedical Engineering: Specialisation Medical Tele	•		
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S			
	Product Development, Materials and Production: S	pecialisation Materials: Elective Compulsor	y	
	Theoretical Mechanical Engineering: Technical Cor	nplementary Course: Elective Compulsory		
	Theoretical Mechanical Engineering: Core Qualifica	ation: Elective Compulsory		

Course L0658: Optimal and F	Robust Control		
Тур	Lecture		
Hrs/wk	2		
СР	3		
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28		
Lecturer	Prof. Herbert Werner		
Language	EN		
Cycle	SoSe		
Content	 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 		

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

Courses				
Title		Тур	Hrs/wk	СР
Marketing of Innovations (L2009) PBL Marketing of Innovations (L086	52)	Lecture Project-/problem-based Learning	4 1	4 2
-		Project-/problem-based Learning		2
Module Responsible	·			
Admission Requirements	None			
Recommended Previous Knowledge	Module International Business			
Knowledge	Basic understanding of business administration	on principles (strategic planning, decisi	on theory, p	roject managemer
	international business)			
	Bachelor-level Marketing Knowledge (Marketing)	Instruments, Market and Competitor Strat	tegies, Basics	of Buying Behavior
	Unerstanding the differences beweetn B2B and limits.			
	Understanding of the importance of managing in	inovation in global industrial markets		
	Good English proficiency; presentation skills			
Educational Objectives	After taking part successfully, students have reached t	he following learning results		
Professional Competence				
Knowledge	Students will have gained a deep understanding of			
	Specific characteristics in the marketing of innov Approaches for applying the surrent market situ	·	+	
	 Approaches for analyzing the current market siti The gathering of information about future custor 		L	
	Concepts and approaches to integrate lead user	·	develonment	nrocesses
	Approaches and tools for ensuring customer-orie			
	Marketing mix elements that take into consider			
	services	·	J	·
	Pricing methods for new products and services			
	 The organization of complex sales forces and pe 	rsonal selling		
	Communication concepts and instruments for ne	ew products and services		
Skills	Based on the acquired knowledge students will be able	to:		
	 Design and to evaluate decisions regarding mark 	keting and innovation strategies		
	Analyze markets by applying market and technol			
	Conduct forecasts and develop compelling scenarios.			
	Translate customer needs into concepts, protot		fully apply ad	vanced methods fo
	customer-oriented product and service developr	nent		
	 Use adequate methods to foster efficient diffusion 	on of innovative products and services		
	 Choose suitable pricing strategies and communi 	cation activities for innovations		
	Make strategic sales decisions for products and	services (i.e. selection of sales channels)		
	Apply methods of sales force management (i.e.	customer value analysis)		
Personal Competence				
•	The students will be able to			
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				
	have fruitful discussions and exchange argument	ts		
	develop original results in a group			
	present results in a clear and concise way carry out respectful team work			
	carry out respectful team work			
	The state of the 190 to			
Autonomy	The students will be able to			
	Acquire knowledge independently in the specific	context and to map this knowledge on ot	her new comp	lex problem fields.
	 Consider proposed business actions in the field of 	of marketing and reflect on them.		
Workload in House	Independent Study Time 110 Study Time in Lecture 76	<u> </u>		
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70)		
Credit points				
Course achievement	None Subject theoretical and practical work			
Examination	Subject theoretical and practical work	icination		
Examination duration and scale	Written elaboration, excercises, presentation, oral part	icipation		
	Clobal Tachnology and Innevation Management S. Enter	opropourship, Coro Qualification, Co	-on/	
Assignment for the	Global Technology and Innovation Management & Entre		•	
Following Curricula	International Management and Engineering: Specialisa Mechanical Engineering and Management: Specialisation		ripuisui y	
	Biomedical Engineering and Management: Specialisation Biomedical Engineering: Specialisation Artificial Organs		npulsory	
	Biomedical Engineering: Specialisation Implants and Er			
	Biomedical Engineering: Specialisation Medical Techno		sory	
	Biomedical Engineering: Specialisation Management ar		-	
		· · · · · · · · · · · · · · · · · · ·		

Course L2009: Marketing of	Innovations
Тур	Lecture
Hrs/wk	4
СР	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
	EN
Cycle Content	I. 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
	Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis
	V. Customer-oriented Product and Service Engineering
	Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting
	VII. Pricing
	Basics of Pricing, Value-based pricing, Pricing models
	VIII. Sales Management
	Basics of Sales Management, Assessing Customer Value, Planning Customer Visits
	IX. Communications
	Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335. Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).
	Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008
	Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24.
	Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4 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

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

Courses				
Title		Тур	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)		Lecture	2	3
Bioprocess Engineering- Fundamer		Recitation Section (larg		1
Bioprocess Engineering - Fundame		Practical Course	2	2
Module Responsible	Prof. Andreas Liese			
Admission Requirements	None			
Recommended Previous	none, module "organic chemistry", module "	fundamentals for process engineering"		
Knowledge				
Educational Objectives	After taking part successfully, students have	reached the following learning results		
Professional Competence				
Knowledge	Students are able to describe the basic cond	epts of bioprocess engineering. They are	able to classify differer	nt types of kinetics
	enzymes and microorganisms, as well as	to differentiate different types of inhibit	tion. The parameters	of stoichiometry a
	rheology can be named and mass transpo	rt processes in bioreactors can be expla	ained. The students a	re capable to expl
	fundamental bioprocess management, steril	ization technology and downstream proces	ssing in detail.	
Skille	After successful completion of this module, s	tudents should be able to		
SKIIIS	Acce succession completion of this module, s	stadents silvaid be able to		
	 describe different kinetic approaches 	for growth and substrate-uptake and to ca	Iculate the correspond	ing parameters
	 predict qualitatively the influence of 	energy generation, regeneration of redo	x equivalents and gro	owth inhibition on
	fermentation process			
	 analyze bioprocesses on basis of stoic 	hiometry and to set up / solve metabolic f	lux equations	
	distinguish between scale-up criteria	for different bioreactors and bioprocesses	(anaerobic, aerobic as	well as microaerol
	to compare them as well as to apply t	hem to current biotechnical problem		
	 propose solutions to complicated biot 	echnological problems and to deduce the	corresponding models	
	to a decrease to determine			
	to explore new knowledge resources and the state of			
	· ·	rete industrial use and to formulate solutio		
	• to document and discuss their proced	ures as well as results in a scientific mann	ei	
Personal Competence				
Social Competence	·			
	take position to their own opinions and incre	ase their capacity for teamwork in engine	ering and scientific env	rironments.
Autonomy	After completion of this module participants	will be able to solve a technical problem	in a team independen	tly by organizing th
riaconomy	workflow and to present their results in a pl		a coa macpenaen	ay by organizing a
	moranon and to present them results in a pr			
Workload in Hours	Independent Study Time 96, Study Time in L	ecture 84		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes 5 % Subject theoretical	and		
	practical work			
Examination	Written exam			
Examination duration and	90 min			
scale				
	6	7		
Assignment for the	General Engineering Science (German progr	•		
Following Curricula	General Engineering Science (German progr		s Engineering: Compuls	sury
	Bioprocess Engineering: Core Qualification: (, ,		
	General Engineering Science (English progra	•		
	General Engineering Science (English progra			ory
	Biomedical Engineering: Specialisation Artification	•		
	Biomedical Engineering: Specialisation Impla			
	Biomedical Engineering: Specialisation Medi	**		
	Biomedical Engineering: Specialisation Mana		tive Compulsory	
	Technomathematics: Specialisation III. Engir			
	Process Engineering: Core Qualification: Con	npulsory		

Course L0841: Bioprocess En	igineering - Fundamentals
Тур	Lecture
Hrs/wk	2
СР	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, 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 En	gineering- Fundamentals
Тур	Recitation Section (large)
Hrs/wk	2
СР	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese, Prof. An-Ping Zeng
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng)
	2. Enzymatic kinetics (Prof. Liese)
	3. Stoichiometry I + II (Prof. Liese)
	4. Microbial Kinetics I+II (Prof. Zeng)
	5. Rheology (Prof. Liese)
	6. Mass transfer in bioprocess (Prof. Zeng)
	7. Continuous culture (Chemostat) (Prof. Zeng)
	8. Sterilisation (Prof. Zeng)
	9. Downstream processing (Prof. Liese)
	10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

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

Module M1143: Mechanical Design Methodology					
Courses					
Title		Тур		Hrs/wk	СР
Mechanical Design Methodology (L	1523)	Lect	ure	3	4
Mechanical Design Methodology (L	1524)	Reci	tation Section (small)	1	2
Module Responsible	Prof. Josef Schlattmann				
Admission Requirements	None				
Recommended Previous					
Knowledge					
Educational Objectives	After taking part successfully, students have	e reached the following le	arning results		
Professional Competence					
Knowledge	Science-based working on product design co	onsidering targeted applic	ation of specific product	design technique	es
Skills	Creative handling of processes used for science	antific proparation and for	mulation of complex pro	dust dosign prob	lome / Application of
SKIIIS	various product design techniques following		indiation of complex pro-	auct design prob	nems / Application of
	various product design techniques following	g theoretical aspects.			
Personal Competence					
Social Competence					
Autonomy					
Workload in Hours	Independent Study Time 124, Study Time in	Lecture 56			
Credit points	6				
Course achievement	None				
Examination	Oral exam				
Examination duration and	30 min				
scale					
Assignment for the	International Management and Engineering	: Specialisation II. Product	Development and Produ	ction: Elective Co	ompulsory
Following Curricula	Mechatronics: Specialisation System Design	: Elective Compulsory			
	Biomedical Engineering: Specialisation Artif	icial Organs and Regenera	tive Medicine: Elective C	ompulsory	
	Biomedical Engineering: Specialisation Impl	ants and Endoprostheses:	Elective Compulsory		
	Biomedical Engineering: Specialisation Medi	ical Technology and Contr	ol Theory: Elective Comp	ulsory	
	Biomedical Engineering: Specialisation Man	agement and Business Ad	ministration: Elective Co	mpulsory	
	Theoretical Mechanical Engineering: Special	lisation Product Developm	ent and Production: Elec	tive Compulsory	
	Theoretical Mechanical Engineering: Technic	cal Complementary Cours	e: Elective Compulsory		

Course L1523: Mechanical De	esign 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 De	esign 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: MED I	l: Introduction to Anatomy	
Courses		
Title	Typ Hrs/wk CP	
Introduction to Anatomy (L0384)	Lecture 2 3	
Module Responsible	Prof. Udo Schumacher	
Admission Requirements	None	
Recommended Previous	None	
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can describe basal structures and functions of internal organs and the musculoskeletal system.	
	The students can describe the basic macroscopy and microscopy of those systems.	
Skills	The students can recognize the relationship between given anatomical facts and the development of some common diseases; the	
	can explain the relevance of structures and their functions in the context of widespread diseases.	
Personal Competence		
Social Competence	The students can participate in current discussions in biomedical research and medicine on a professional level.	
Autonomy	The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acqui	
	the relevant knowledge themselves.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points		
Course achievement		
Examination		
Examination duration and		
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic	
	Compulsory	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic	
	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	

avT	Lecture	
Hrs/wk		
СР		
Workload in Hours	Independent Study	Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Lange	
Language	DE	
Cycle		
Content	General Anatomy	
	1 st week:	The Eucaryote Cell
	2 nd week:	The Tissues
	Z*** 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
	7 th week:	Genito-urinary System
	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/Michael	Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

Module M1280: MED	II: Introduction to Physiology
Courses	
Title	Typ Hrs/wk CP
Introduction to Physiology (L0385)	Lecture 2 3
Module Responsible	Dr. Roger Zimmermann
Admission Requirements	None
Recommended Previous	None
Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can
	describe the basics of the energy metabolism;
	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
SKIIIS	of forces and vital functions) and relate them to similar technical systems.
Personal Competence	of forces and what functions, and refuce them to similar teermical systems.
•	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	None
Examination	Written exam
Examination duration and	60 minutes
scale	
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Following Curricula	
	Compulsory
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanic
	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, Dr. Roger Zimmermann
Language	DE
Cycle	SoSe
Content	
Literature	Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme
	Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier

Module M1278: MED I	l: Introduction to Radiology and Radiation Therapy
Courses	
Title	Typ Hrs/wk CP
Introduction to Radiology and Radio	
Module Responsible	
Admission Requirements Recommended Previous	
Knowledge	Note
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Therapy The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.
	The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).
	The students can describe the patients' passage from their initial admittance through to follow-up care.
	Diagnostics
	The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).
	The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.
	The students can choose the right treatment method depending on the patient's clinical history and needs.
	The student can explain the influence of technical errors on the imaging techniques.
	The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	Therapy
	The students can distinguish curative and palliative situations and motivate why they came to that conclusion.
	The students can develop adequate therapy concepts and relate it to the radiation biological aspects.
	The students can use the therapeutic principle (effects vs adverse effects)
	The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).
	The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).
	Diagnostics
	The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.
	The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology.
Personal Competence	
Social Competence	The students can assess the special social situation of tumor patients and interact with them in a professional way. The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately.
Autonomy	The students can apply their new knowledge and skills to a concrete therapy case. The students can introduce younger students to the clinical daily routine.
	The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves.
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Credit points	3
Course achievement	
Examination Examination duration and	90 minutes
scale	30
Assignment for the Following Curricula	
	Electrical Engineering: Specialisation Medical Technology: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics Compulsory Constal Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering Compulsory
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory

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

Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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

Module M1332: BIO I:	: Experimental Methods in Biomechanics	
Courses		
Title	Typ Hrs/wk	СР
Experimental Methods in Biomecha	anics (L0377) Lecture 2	3
Module Responsible	Prof. Michael Morlock	
Admission Requirements	None	
Recommended Previous	It is recommended to participate in "Implantate und Frakturheilung" before attending "Experimentelle Methoden"	'.
Knowledge		
Educational Objectives	After taking part successfully, students have reached the following learning results	
Professional Competence		
Knowledge	The students can describe the different ways how bones heal, and the requirements for their existence.	
	The students can name different treatments for the spine and hollow bones under given fracture morphologies.	
	The students can describe different measurement techniques for forces and movements, and choose the adequa	te technique for a
	given task.	
Skills	The students can describe the basic handling of several experimental techniques used in biomechanics.	
Personal Competence		
	The students can, in groups, solve basic experimental tasks.	
Social Competence	The students can, in groups, solve basic experimental tasks.	
Autonomy	The students can, in groups, solve basic experimental tasks.	
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28	
Credit points	3	
Course achievement	None	
Examination	Written exam	
Examination duration and	90 min	
scale		
Assignment for the	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Foc	us Biomechanics:
Following Curricula	Compulsory	
	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Foci	us Biomechanics
	Compulsory	
	General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory	
	Mechanical Engineering: Specialisation Biomechanics: 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	
	recimomathematics. Specialisation III. Engineering Science: Elective Compulsory	

Course L0377: Experimental	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: BIO II	: Artificial Joint Replacement			
Courses				
Title		Тур	Hrs/wk	СР
Artificial Joint Replacement (L1306		Lecture	2	3
Module Responsible	Prof. Michael Morlock			
Admission Requirements	None			
Recommended Previous	Basic knowledge of orthopedic and surgical technic	ques is recommended.		
Knowledge				
Educational Objectives	After taking part successfully, students have reach	ed the following learning results		
Professional Competence				
Knowledge	The students can name the different kinds of artific	cial limbs.		
Skills	The students can explain the advantages and disag	duantages of different kinds of ender	arothosos	
SKIIIS	The students can explain the advantages and disac	availages of different kinds of endop	notheses.	
Personal Competence				
Social Competence	The students are able to discuss issues related to $\boldsymbol{\varepsilon}$	endoprothese with student mates and	d the teachers.	
Autonomy	The students are able to acquire information on the	eir own. They can also judge the info	rmation with respect to	its credibility.
Workload in Hours	Independent Study Time 62, Study Time in Lecture	28		
Credit points				
Course achievement				
Examination				
Examination duration and	90 min			
scale	30 111111			
Assignment for the	International Management and Engineering: Specia	alisation II Process Engineering and F	Riotechnology: Flective	Compulsory
Following Curricula	Materials Science: Specialisation Nano and Hybrid		order moregy. Erecute	pu.50. y
3 · · · · ·	Biomedical Engineering: Specialisation Artificial Ord		ctive Compulsory	
	Biomedical Engineering: Specialisation Implants an	•	, ,	
	Biomedical Engineering: Specialisation Medical Tec	chnology and Control Theory: Elective	e Compulsory	
	Biomedical Engineering: Specialisation Managemen	nt and Business Administration: Elect	ive Compulsory	
	Orientierungsstudium: Core Qualification: Elective	Compulsory		
	Theoretical Mechanical Engineering: Technical Com	nplementary Course: Elective Compu	Isory	
	Theoretical Mechanical Engineering: Specialisation	Bio- and Medical Technology: Elective	ve Compulsory	

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

Module M0845: Feed	back Control in Medical Te	chnology		
Courses				
Title		Тур	Hrs/wk	СР
Feedback Control in Medical Techn	ology (L0664)	Lecture	2	3
Module Responsible	Johannes Kreuzer			
Admission Requirements	None			
Recommended Previous	Basics in Control, Basics in Physiology			
Knowledge				
Educational Objectives	After taking part successfully, student	s have reached the following learning results		
Professional Competence				
Knowledge		scinating area of medical technology with the er roduced like knowledge in control theory.	ngineering point of vie	w. Fundamentals ir
	Internal control loops of the human lexample in for anesthesia control.	body will be discussed in the same way like the	design of external clo	osed loop system f
	The handling of PID controllers and illustrated. The operation of simple eq	modern controller like predictive controller or fu uivalent circuits will be discussed.	izzy controller or neui	ral networks will b
Skills	Application of modeling, identification,	, control technology in the field of medical technolo	ogy.	
Personal Competence				
Social Competence	Students can develop solutions to spec	cific problems in small groups and present their re	sults	
Autonomy		terature and to set it into the context of the lectu of their learning process. They can combine kno	•	-
Workload in Hours	Independent Study Time 62, Study Tin	me in Lecture 28		
Credit points	3			
Course achievement	None			
Examination	Oral exam			
Examination duration and	20 min			
scale				
Assignment for the	Electrical Engineering: Specialisation N	Medical Technology: Elective Compulsory		
Following Curricula	Electrical Engineering: Specialisation (Control and Power Systems Engineering: Elective C	ompulsory	
	Biomedical Engineering: Specialisation	n Implants and Endoprostheses: Elective Compulso	ry	
	Biomedical Engineering: Specialisation	n Artificial Organs and Regenerative Medicine: Elec	tive Compulsory	
	Biomedical Engineering: Specialisation	n Management and Business Administration: Election	ve Compulsory	
	Biomedical Engineering: Specialisation	n Medical Technology and Control Theory: Compuls	sory	

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

ourses				
ourses				
itle dvanced Topics in Control (L0661)	Typ Lecture	Hrs/wk 2	CP 3
dvanced Topics in Control (L0662		Recitation Section (small)	2	3
Module Responsible			_	
Admission Requirements	H-infinity optimal control, mixed-sensitivity de	sign linear matrix inequalities		
Kecommended Previous Knowledge		sign, illiear matrix mequalities		
Educational Objectives		eached the following learning recults		
		eached the following learning results		
Professional Competence				
Knowledge	Students can explain the advantages ar	nd shortcomings of the classical gain scheduli	ng approach	
	They can explain the representation of its area.	nonlinear systems in the form of quasi-LPV sy	stems	
	They can explain how stability and performance	ormance conditions for LPV systems can be fo	rmulated as LMI co	onditions
	They can explain how gridding technique	es can be used to solve analysis and synthes	s problems for LPV	/ systems
	They are familiar with polytopic and	LFT representations of LPV systems and so	me of the basic s	synthesis techniq
	associated with each of these model str	uctures		
	Students can explain how graph theo	retic concepts are used to represent the o	ommunication top	oology of multiag
	systems			
	They can explain the convergence property.	erties of first order consensus protocols		
	They can explain analysis and synthesis	conditions for formation control loops involved	ng either LTI or LP	V agent models
	Students can explain the state space re	presentation of spatially invariant distributed	systems that are	discretized accord
	to an actuator/sensor array			
	They can explain (in outline) the external	nsion of the bounded real lemma to such o	istributed systems	s and the associa
	synthesis conditions for distributed cont	rollers		
Skills				
51.11.5		LPV models of nonlinear plants and carry of	ut a mixed-sensit	tivity design of g
	scheduled controllers; they can do this	using polytopic, LFT or general LPV models		
	They are able to use standard software	tools (Matlab robust control toolbox) for these	e tasks	
		formation controllers for groups of agents	with either LTI or	LPV dynamics, us
	Matlab tools provided			
	Students are able to design distributed	controllers for spatially interconnected syster	ns, using the Matla	b MD-toolbox
Personal Competence				
•	Students can work in small groups and arrive a	at joint results		
Autonomy		•	software docume	ntation) and use i
Autonomy	solve given problems.	in sources provided (lecture notes, interactive	, software docume	intation) and use
	Solve given problems.			
Workload in Hours	Independent Study Time 124, Study Time in Le	ecture 56		
Credit points				
Course achievement				
Examination			-	
Examination duration and				
scale				
Assignment for the		Engineering: Elective Compulsory		
Following Curricula			nulsory	
r onowing curricula	Aircraft Systems Engineering: Specialisation Control a	, , ,	paisor y	
	Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialisation Aircraft Systems Engineering: Specialis			
	International Management and Engineering: Specialisation Av		Isory	
	Mechatronics: Specialisation System Design: E		1301 y	
	Mechatronics: Specialisation System Design: E Mechatronics: Specialisation Intelligent System			
	Biomedical Engineering: Specialisation Implant	· · ·		
		is and Endoprostneses: Elective Compulsory I Technology and Control Theory: Elective Col	mnulsory	
			IIIVUIDUI V	
		•		
	Biomedical Engineering: Specialisation Medical Biomedical Engineering: Specialisation Manage Biomedical Engineering: Specialisation Artificia	ement and Business Administration: Elective	Compulsory	

Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Typ	Lecture
Hrs/wk	
СР	
	Independent Study Time 62, Study Time in Lecture 28
	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, l2 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	Warren Harris and Alberta Tarket Controller
	Werner, H., Lecture Notes "Advanced Topics in Control"

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

Module M0635: Medic	al Technology Lab			
Courses				
Title		Тур	Hrs/wk	СР
Medical Technology Lab (L1096)		Project-/problem-based Learning	6	6
Module Responsible	Prof. Alexander Schlaefer			
Admission Requirements	None			
Recommended Previous	sound programming skills (Java / C++)			
Knowledge	skills in R/Matlab			
	knowledge of image processing			
	principles of math (algebra, analysis/calculus)			
	principles of stochastics			
Educational Objectives	After taking part successfully, students have rea	ached the following learning results		
Professional Competence				
Knowledge	The students recognize the complexity of medi	cal technology and can explain, which methods a	are appropriat	e to solve a problem
	at hand.			
Skills	The students are able to analyze and solve prob	olems in medical technology		
SKIIIS	The students are able to analyze and solve proc	ments in medical teermology.		
Personal Competence				
-	The students can define project aims and sco	pe and organize the project as team work. The	ev can preser	nt their results in an
, , , , , , , , , , , , , , , , , , , ,	appropriate manner.	,	, ,	
Autonomy	The students take responsibility for their tasks	and coordinate their individual work with other g	roup member	s. They deliver their
	work on time. They independently acquire addit	ional knowledge by doing a specific literature res	search.	
Workload in Hours	Independent Study Time 96, Study Time in Lect	ure 84		
Credit points	6			
Course achievement	Compulsory Bonus Form	Description		
	Yes None Group discussion			
Examination	Written elaboration			
Examination duration and	approx. 8 pages, time frame: over the course of	the semester		
scale				
Assignment for the	Electrical Engineering: Specialisation Medical Te			
Following Curricula	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Compuls	sory	
	Biomedical Engineering: Specialisation Medical	Technology and Control Theory: Elective Compul	sory	

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

Thesis

Module M-002: Maste	er Thesis
Courses	
Title	Typ Hrs/wk CP
Module Responsible	
Admission Requirements	
	According to General Regulations §21 (1):
	At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	Arter taking part successivily, stateties have reactical the following learning results
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.
Porcenal Competence	
Personal Competence Social Competence	Students can
Social competence	Staden's cui
	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.
	while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able:
	 To structure a project of their own in work packages and to work them off accordingly. To work their way in depth into a largely unknown subject and to access the information required for them to do so.
	 To apply the techniques of scientific work comprehensively in research of their own.
	- To apply the teeningues of selectaine work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	
Examination	
examination duration and scale	According to General Regulations
	Civil Engineering: Thesis: Compulsory
_	Bioprocess Engineering: Thesis: Compulsory
3	Chemical and Bioprocess Engineering: Thesis: Compulsory
	Computer Science: Thesis: Compulsory
	Electrical Engineering: Thesis: Compulsory
	Energy and Environmental Engineering: Thesis: Compulsory
	Energy Systems: Thesis: Compulsory
	Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory
	Global Innovation Management: Thesis: Compulsory
	Computational Science and Engineering: Thesis: Compulsory
	Information and Communication Systems: Thesis: Compulsory
	International Management and Engineering: Thesis: Compulsory
	Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory
	Logistics, Infrastructure and Mobility: Thesis: Compulsory
	Materials Science: Thesis: Compulsory
	Mathematical Modelling in Engineering: Theory, Numerics, Applications: Thesis: Compulsory
	Mechanical Engineering and Management: Thesis: Compulsory

Module Manual M.Sc. "Biomedical Engineering"

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