OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

EIT FAKULTÄT FÜR ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Module descriptions

Master

Medical Systems Engineering

March 6, 2019

Contents

Advances in Radiation and Medical Physics

Objectives and content	**Objectives:** **Content:**
Literature	
Teaching	Lecture, Tutorial, Lab Project
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Lab certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (70 h time of attendance + 80 h autonomous work)
Work load	Time of attendance in winter semester: 2 SWS Lecture, 1 SWS Tutorial Time of attendance in summer semester: 2 SWS Lab Project Autonomous work: Preparation of the lectures, tutorials and lab project, preparation of the exam
Frequency	Starts every winter semester
Duration	Two semesters
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Applied Neuroscience - from study design in motor research to brain-computer-interfaces

Objectives and content	**Objectives:** This module comprises a seminar and a lab project. In the seminar, students will learn how concepts and methods borrowed from engineering have provided fundamental insight into principles of human motor control. Following a brief introduction to the anatomy and physiology of the human motor system, students will become familiar with important challenges and problems in human motor control, as well as approaches to solve them. They will read, and learn to summarize, present, and critically review, selected seminal experimental research in this field. In the lab project, students will learn to apply several key methods used in human neuroscience. They will acquire knowledge about the acquisition, visual inspection and analysis of electroencephalographic (EEG) signals, learn appropriate algorithms for feature extraction and classification, and become familiar with basic problems of brain-computer-interfaces (BCI). At the end of the lab project, they will be able to process the discussed problems by autonomously applying the learned algorithms. By programming of a computer game control via EEG-signals, students will be able to deepen their knowledge and skills in a research oriented way and to apply and evaluate it on complex problems. **Content:** ▪ Introduction/Theoretical background: ▫ Anatomy and physiology of the human motor system ▫ Fundamental problems in human motor control, and concepts and methods borrowed from engineering to solve them ▫ Basic principle BCI ▫ EEG ▫ Feature extraction ▫ Classification ▫ Steady State Visually Evoked Potentials (SSVEP) ▪ Critical scientific reading, introduction to the human motor neuroscience
Literature	[1] Acquisition of EEG-signals [2] Artifact detection [3] Programming of a computer game control via SSVEP
Teaching	Seminar, Lab Project
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Experimental work
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 1 SWS Seminar, 2 SWS Lab Project Autonomous work: Preparation of the seminars and lab project, preparation of the exam
Frequency	Every summer semester
Duration	One semester

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Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Basics of Radiation Physics and Image Science

Objectives and content	**Objectives:** The student will: ▪ get on overview about radiation principles including types of ionizing radiation and their behaviour ▪ learn about the biological effects of ionizing radiation ▪ become aquainted with dosimetry ▪ get to know to system theory for medical imaging systems ▪ learn to understand the differences between Fourier based and task based image quality descriptions ▪ understand how image quality can be described by different types of observers (human and model observers) **Content:** ▪ Radiation Physics for alpha-, beta-, gamma-, neutron- and X-ray radiation ▪ Dosimetry ▪ MTF, NPS and DQE ▪ Ideal observer, human observer models, ROC curves
Literature	provided by e-learning system
Teaching	Lecture, Seminar
Prerequisites	Mathematics, Physics, Fundamentals in Electrical Engineering
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	4 CP = 120 h (56 h time of attendance + 64 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Seminar Autonomous work: Rework of lectures and tutorial, preparation of excersices
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Biological Statistics

Objectives and content	**Objectives:** The student will ▪ understand the fundamentals of statistics and probability theory ▪ have an overview about the standard methods of statistics ▪ learn to understand and interpret statistical results correctly ▪ be able to communicate statistical results ▪ and to transfer them back to real world problems **Content:** Central concepts of statistics and probability theory, insofar as relevant to medical systems engineering: ▪ descriptive statistics ▪ probability ▪ inferential statistics ▪ estimation and hypothesis testing ▪ analysis of variance ▪ correlation and regression ▪ general linear models ▪ non-parametric methods
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. habil. Rainer Schwabe (FMA-IMST)

Computational Biomechanics

Objectives and content	**Objectives:** The lecture is aimed to provide the students with knowledge and skills in computational mechanics to solve engineering problems (statics, strength of materials, dynamics). The lecture provides an introduction into the mathematical modeling and the computational analysis of engineering problems. The students receive the ability to solve simplified technical problems with a reference to biomechanical and medical engineering. **Content:** ▪ Overview about modern computational methods in mechanics and there application in biomechanics and medical engineering ▪ Introduction in mathematical modeling ▪ Discretization methods: ▫ Finite difference method (FDM) ▫ Energy Methods (Ritz, Galerkin) ▫ Finite element method (FEM) ▫ Multi body dynamics (MBS) ▪ Computational analysis of selected problems in biomechanics
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: re-working of lectures, autonomous execution of exercises, preparation of the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr.-Ing. Daniel Juhre (FMB-IFME)

Computational Fluid Dynamics

Objectives and content	**Objectives:** Numerical flow simulation (usually called Computational Fluid Dynamics or CFD) is playing an essential role in many modern industrial projects. Knowing the basics of fluid dynamics is very important but insufficient to be able to learn CFD on its own. In fact the best way of learning CFD is by relying to a large extent on "learning by doing" on the PC. This is the purpose of this Module, in which theoretical aspects are combined with many hands-on and exercises on the PC. By doing this, students are able to use autonomously, efficiently and target-oriented CFD-programs in order to solve complex fluid dynamical problems. They also are able to analyse critically CFD-results. **Content:** ▪ Introduction and organization. Historical development of CFD. Importance of CFD. Main methods (finite-differences, -volumes, -elements) for discretization. ▪ Vector and parallel computing. How to use supercomputers, optimal computing loop, validation procedure, Best Practice Guidelines. ▪ Linear systems of equations. Iterative solution methods. Examples and applications. Tridiagonal systems. Realization of a Matlab-Script for the solution of a simple flow in a cavity (Poisson equation), with Dirichlet-Neumann boundary conditions. ▪ Choice of convergence criteria and tests. Grid independency. Impact on the solution. ▪ Introduction to finite elements on the basis of COMSOL. Introduction to COMSOL and practical use based on a simple example. ▪ Carrying out CFD: CAD, grid generation and solution. Importance of gridding. Best Practice (ERCOFTAC). Introduction to Gambit, production of CAD-data and grids. Grid quality. ▪ Physical models available in Fluent. Importance of these models for obtaining a good solution. Introduction to Fluent. Influence of grid and convergence criteria. First- and second-order discretization. Grid-dependency. ▪ Properties and computation of turbulent flows. Turbulence modeling. Computation of a turbulent flow behind a backward-facing step. Dispatching subjects for the final project.
Literature	Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer
Teaching	Lecture, Research Project
Prerequisites	Fluid mechanics
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Research project
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Research Project Autonomous work: Preparation of the lectures, literature research
Frequency	Every summer semester
Duration	One semester

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Responsible person	Priv.-Doz. Dr.-Ing. Gabor Janiga (FVST-ISUT)

Computed Tomography

Teaching	Lecture, Tutorial, Lab Project
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Examination	Written examination 120min
Credit Points	10 CP = 300 h (126 h time of attendance + 174 h autonomous work)
Work load	Time of attendance: 5 SWS Lecture, 2 SWS Tutorial, 2 SWS Lab Project
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Sub-Module: Methods on Computed Tomography

Objectives and content	**Objectives:** The student will: ▪ understand the system theory of imaging systems ▪ learn the functional principle of the computed tomography ▪ understand the mathematical principle of tomographic reconstruction ▪ have an overview about the current research work in the area of tomographic imaging **Content:** Starting with the system theory of imaging systems, the first part of the module is focused on the physical properties of x-rays and it's interaction with manner. The second part deals with X-ray based standard radiography. The third and final part brings the mathematical methods of tomographic image reconstruction into focus. The particular content is: ▪ System theory of imaging systems ▪ Basic principle of underlying physics ▪ X-ray tubes and detectors ▪ Radiography ▪ Reconstruction: Fourier-based principle, Filtered back projection, Algebraic approach, statistical methods ▪ Beam-geometry: Parallel-, Fan- and Conebeam ▪ Implementation ▪ Artefacts and Adjustment
Literature	Kak, Slaney: Principles of computerized tomographic imaging; Kalender: Computed Tomography
Teaching	Lecture, Tutorial
Prerequisite for the admission to any examination	Tutorial certificate
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Rework of lectures and tutorial, preparation of excersices

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Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Sub-Module: Industrial Applications of Computed Tomography

Objectives and content	**Objectives:** The student will: ▪ Be able to classify the different NDT Methods and their importance for the quality assurance in modern manufacturing processes ▪ Learn from what possible image resolution (spatial and contrast) depends on ▪ Understands how the CT as coordination measurement machine works ▪ Apply the theory of measurement error and uncertainty to the CT usage ▪ Get information about the principles of structural examinations of objects and the possibility of automatic analyses. ▪ Be informed about different standards and the ongoing process of standardisation. ▪ Have the possibility to plan CT examinations for material testing properly **Content:** At first a general overview about the usage of CT Systems for industrial purposes is given. The differences and similarities to medical applications are explained. The process of image acquisition will be repeated. Core theme is the dependency between x- ray physics, machine parameters and resolution. Then the CT as a coordinate measuring system is introduced. Afterwards the methods to register a digital copy of an object in coordinate systems and the measurement process itself including the acquisition of geometric tolerances is in focus. The next part of the module is dedicated to the basic problem of all measurement effort: the measurement error and the industrial method to cope with uncertainty. The structure examination with CT and the methods of automatic analyses will be discussed. At the end of the module the current state of standardisation and their application will be a subject. ▪ Overview about non-destructive testing, its technique and application with consideration of the economic context and Industry 4.0 ▪ Process chain of data processing, indicators for image quality and resolution ▪ CT as coordinate measuring system. Registration and measuring methods ▪ Measuring error and gauge capability ▪ CT for structural examination ▪ Standardisation and the process of finding appropriated scan parameters
Literature	
Teaching	Lecture
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 1 SWS Lecture Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. Lutz Hagner (Microvista GmbH)

Sub-Module: Lab course CT

Objectives and content	**Objectives:** The student will: ▪ apply the theoretical knowledge from the sub-module "Medical Imaging - Computed Tomography" ▪ get a deeper understanding of the properties of data acquired by CT scanners ▪ learn to assert image quality ▪ practice processing CT dataset and reconstruction in MATLAB (or C/C++) ▪ be stimulated to think about alternative methods to solve problems analytically Required qualifications: ▪ sub-module "Medical Imaging - Computed Tomography" ▪ basic programming skills **Content:** The student has the choice between a practical task in the angiography lab including measurements and quantitative evaluation (angiography lab course), or to solve programming tasks with simulated data (computer lab course). Angiography lab course: The student will use a hardware performance phantom in order to evaluate the image quality of a clinical C-arm system. For this purpose, the student will perform measurements and export the data sets of the reconstructed images. For this, the student has to implement several routines to quantify the image quality. Finally, the results have to be analyzed and discussed. Computer lab course: The student will work on several programming tasks with different degrees of difficulty, covering a variety of typical problems in CT imaging. Usually, a data set consisting of simulated CT projections will be given. The task can be solved via an appropriate reconstruction or with creative analysis. Finally, the solution strategy has to be documented and discussed.
Literature	Buzug, Thorsten: Computed Tomography: From Photon Statistics to Modern Cone-Beam CT
Teaching	Lab Project
Prerequisite for the admission to any examination	Lab certificate
Work load	Time of attendance: 2 SWS Lab Project Autonomous work: ▪ 1/6 - theoretical preparation (literature research) ▪ 1/6 - performing the measurement resp. theoretical analysis ▪ 1/3 - implementation of the routines ▪ 1/6 - evaluation and visualization ▪ 1/6 - preparing a talk or report The full lab course has to be done in an autonomous work.
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Computer Aided and Image Guided Interventions

Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Examination	Seminar paper
Credit Points	8 CP = 240 h (56 h time of attendance + 184 h autonomous work)
Work load	Time of attendance: 1 SWS Lecture, 3 SWS Seminar
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr. Christian Hansen (FIN-ISG)

Sub-Module: Computer-Assisted Surgery

Objectives and content	**Objectives:** Computer-assisted surgery is an interdisciplinary research field that builds a bridge between surgery and computer science. It represents a set of methods which use computer technology to support preoperative planning, the actual surgery, and postoperative assessment. This lecture will offer an overview of computer-assisted surgery. After an introduction of fundamentals, the state of the art in computer-assisted surgery is presented on the basis of clinical examples. **Content:** ▪ Fundamentals of Intraoperative Imaging ▪ Fundamentals of Surgical Visualization ▪ Computer-Assisted Surgery Planning ▪ Surgical Navigation Systems ▪ Surgical Augmented Reality ▪ Surgeon-Computer Interaction ▪ Robotic Surgery ▪ Development and Evaluation of Medical Software
Literature	
Teaching	Lecture, Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 1 SWS Lecture, 2 SWS Seminar Autonomous work: Preparation of the lectures and seminars
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr. Christian Hansen (FIN-ISG)

Sub-Module: Medical Imaging in Interventional Endovascular Therapy

Objectives and content	**Objectives:** The students will: ▪ gain knowledge of basic interventional procedures ▪ understand the techniques of interventional treatment ▪ have an overview about imaging tasks and modalities for interventions ▪ learn about issues related to interventional treatment **Content:** The course is meant to provide a basic knowledge of the medical imaging techniques that are used in the endovascular interventional therapy of the vessel disease. The pathological conditions and the characteristics of the image guided therapy applied to treat the diseases will be also briefly elaborated. The course is consist of the following teaching blocks: ▪ Vascular disease ▪ Interventional ▪ Interventional imaging vs vascular surgery ▪ Interventional suite ▪ Preinterventional scanning in acute patients ▪ Interventional X-ray based 2D and 3D techniques ▪ Endovascular therapy of intracranial ▪ Endovacular therapy of AVM's ▪ Endovascular therapy of intracranial tumors ▪ Endovascular therapy of spine disease ▪ Functional imaging ▪ Post-interventional check up ▪ New technical developments in endovascular interventional imaging ▪ Pre-interventional virtual therapy planning ▪ New endovascular therapies on the horizon
Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 1 SWS Seminar Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Dr. Drazenko Babic (Philips)

Computer Vision and Deep Learning

Objectives and content	**Objectives:** ▪ Understanding in the abilities of model-based vs. trained image analysis ▪ Understanding in the capabilities of different network architectures in image analysis ▪ Ability to solve a moderately difficult image analysis task **Content:** ▪ Predefined and trained feature detection and feature reduction in images ▪ Discriminative and generative models for image classification ▪ Using neural networks in image classification and object detection ▪ The use of generative models ▪ Video processing using recurrent networks
Literature	See http://wwwisg.cs.uni-magdeburg.de/bv/ and there the lecture website
Teaching	Lecture, Research Project
Prerequisites	Programming skills, basic knowledge in computer vision, basic knowledge in optimization techniques.
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Project certificate ⚠Active participation in the lecture and successful participation in the project
Examination	Oral examination
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Research Project Autonomous work: project development in small groups (2-3), repetition of the lecture topics
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Klaus Tönnies (FIN-ISG)

Development of Bio-MEMS for Medical Engineering

Objectives and content	**Objectives:** The students gain knowledge in the interplay of design, technology, process- and production techniques within the development and manufacturing of Bio-MEMS for medical applications. After finishing the module they will understand the production technologies for Bio-MEMS and will be able to apply the technologies for the conceptual development of miniaturized medical components (e. g. micropumps, microvalves, pressure sensors). Within the practical course they work in the MEMS-cleanroom laboratory and make a Bio-MEMS-device. By means of exercises they learn to deepen their knowledge for further research and to apply it to solve complex problems. **Content:** ▪ MEMS design and simulation ▪ Mask design ▪ MEMS technologies and process flow ▪ Device manufacturing in the cleanroom ▪ Packaging issues
Literature	Fundamentals of microfabrication : the science of miniaturization; Marc J. Madou. - 2. ed. - Boca Raton: CRC Press, 2002, ISBN: 0-8493-0826-7
Teaching	Lecture, Tutorial, Lab Project
Prerequisites	Bachelor in Electrical Engineering or related studies; Module in the Master studies Medical Systems "Mikrosystemtechnik und Nano-Technologien in der Medizintechnik"
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	10 CP = 300 h (84 h time of attendance + 216 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial, 2 SWS Lab Project Autonomous work: Post processing of lectures, preparation of exercises, preparation of practical course, preparation of presentation, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Bertram Schmidt (FEIT-IMOS)

Digital Information Processing

Objectives and content	**Objectives:** ▪ The participant has an overview of basic problems and methods of digital signal processing. ▪ The participant understands the functionality of a digital signal processing system and can mathematically explain the modus of operation. ▪ The participant can assess applications in terms of stability and other markers. He / She can calculate the frequency response and reconstruction of analogue signals. ▪ The participant can perform these calculations and assessments as well on stochastically excited digital systems. ▪ The participant can apply this knowledge in a field of specialization, e. g. Medical Signal Analysis **Content:** 1. Digital Signals and Digital LTI Systems 2. Z-Transform and Difference Equations 3. Sampling and Reconstruction 4. Synthesis and analysis of such systems 5. Discrete and Fast Fourier Transformations 6. Processing of Stochastic Signals by LTI-Systems: Correlation Techniques and Model-Based Systems (ARMA) 7. Selected Specialization Topics, e. g. Medical Signal Analysis
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies Knowledge of signals and systems, Analog Fourier transformations
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: postprocessing of lectures, preparation of exercises and exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)

Digital Information Processing Lab

Objectives and content	**Objectives:** ▪ The participant has an overview of basic methods of applied digital signal processing. ▪ The participant can transform physiological knowledge into technical digital signal processing methods. ▪ Selected Feature Space transformations and their applications are known. ▪ Gaussian Production System Architectures are being estimated under Maximum-Likelihood Assumptions **Content:** 1. Digital Signals and Digital LTI Systems 2. Synthesis and analysis of such systems 3. Discrete and Fast Fourier Transformations 4. Selected Feature Space transformations 5. Gaussian Production System Architectures 6. Characteristics of Human Speech
Literature	
Teaching	Seminar
Prerequisites	Credits obtained in the Course "Digital Signal Processing" (Wendemuth)
Recommended prerequisites	None
Applicability of the module	Applicability of the module Master program
Prerequisite for the admission to any examination	None
Examination	Experimental work
Credit Points	5 CP = 150 h (28 h time of attendance + 122 h autonomous work)
Work load	Time of attendance: 2 SWS Seminar Autonomous work: Pre- and postprocessing of course, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)

Electromagnetic Compatibility (EMC)

Objectives and content	**Objectives:** The students gain information on the fundamental concepts, principles and measurement techniques of Electromagnetic Compatibility (EMC). At the end of the module they are able to understand and apply measures to improve EMC. They will be able to analyze the EMC of systems and know standard measurement procedures. The students know specific EMC demands of medical systems. **Content:** ▪ EMC regulation ▪ EM coupling, shielding, filtering ▪ EMC analysis ▪ Interference models for special applications ▪ EMC measures in electronic circuits ▪ Radiation hazards ▪ Measurement techniques
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Ralf Vick (FEIT-IMT)

Finite Element Method

Objectives and content	**Objectives:** The participants will gain experience in the use of the finite element method (FEM) as a computational method for solving complex systems of differential equations, which are essential in engineering problems. FEM is an effective tool for solving problems in structure and solid mechanics. The students will be taught in the proceeding of assembling the structure problem, its discretization and solving within the FEM. The students experience the exposure to finite element software like Ansys. **Content:** ▪ Fundamentals of the boundary value problem in solid mechanics ▪ Variation calculus and weak form ▪ FE discretization and shape functions ▪ Isoparametric truss elements ▪ Plane finite elements ▪ Volume elements ▪ Extended element technology
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Good skills in mechanics and mathematics
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Postprocessing of lectures, preparation of exercises and exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr.-Ing. Daniel Juhre (FMB-IFME)

Functional Safety for Medical and Technical Systems

Objectives and content	**Objectives:** The lecture provides methods for risk assessment Failure Probability according IEC 61508 as well as principles for risk minimisation. This gives the students skills for functional safety assessments. The studends are able to understand and apply features like probability of failure on demand (PFD), hardware fault tolerance (HFT) and safe failure fraction (SFF)). Probability of malfunctions is characterised and influencing factors are discussed. The Common Course is introduced. The students get skills in analysis medical or general technical systems to identify safety critical behavior and features and how to meet the requirements to design functional safety designs. **Content:** ▪ Basic concepts of functional safety (safety, risk and risk assessment) according to IEC 61508 ▪ Probabilistic approaches for the determination of probability of malfunctions and failures control ▪ Concepts of failure avoidance and software safety ▪ Functional safety is detailed using medicine and specific technical system examples ▪ Standards in this area and their application (IEC 61508 and EN 60601)
Literature	Josef Börcsök: Funktionale Sicherheit. Grundzüge sicherheitstechnischer Systeme. VDE-Verlag. ISBN-10: 3800733056
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, preparation of exercises, preparation of presentation, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Christian Diedrich (FEIT-IFAT)

Human-Computer Interfaces in Medicine

Objectives and content	**Objectives:** The aim of this seminar is to provide an overview about Human-Machine Interaction in medicine. In addition, students can train and improve their skills in scientific reading, presentation and discussion. **Content:** ▪ Human-Machine Interaction in Radiology ▪ Human-Machine Interaction in Surgery ▪ Usability Engineering for Medical Devices ▪ Clinical Evaluation of Human-Machine Interfaces
Literature	
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
Credit Points	4 CP = 120 h (28 h time of attendance + 92 h autonomous work)
Work load	Time of attendance: 2 SWS Seminar Autonomous work: Preparation of the seminars, preparation of the seminar presentation
Frequency	Every summer semester
Duration	One semester
Responsible person	Jun.-Prof. Dr. Christian Hansen (FIN-ISG)

Image Coding

Objectives and content	**Objectives:** Learn about methods and techniques of image coding as essential part in image communication. Problems of image acquisition are treated as far as relevant for image coding. Applications of image coding algorithms in image compression standards and their use in selected fields such as medical imaging are discussed. At the end of the course the students are able to assess existing coding methods for still images and video. They know relevant problems of image acquisition and representation, how the information content in images can be estimated and learn principles in the design of encoders for image and video compression. Students are able to apply image coding methods in medical applications. **Content:** ▪ Acquisition and representation of images ▪ Human perception ▪ Image forming systems ▪ Information theory ▪ Quantisation ▪ Data compression ▪ Lossy coding ▪ Video compression ▪ Transform coding ▪ Content based and semantic coding ▪ Standards and applications
Literature	Many literature on image and video compression is helpful but doesn't replace necessity of being present at classes, e. g. John W. Woods: Multidimensional signal, image, and video processing and coding, Academic Press, 2012, (Online available), material for lecture and exercise is provided by e-learning system
Teaching	Lecture, Tutorial
Prerequisites	Modules typical for Bachelor in Electrical Engineering or related courses
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, solving tasks of exercises, preparation of presentation, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Dr.-Ing. Gerald Krell (FEIT-IIKT)

Introduction in tissue engineering

Objectives and content	**Objectives:** In the lecture, we will start with an introduction into cell biology and signaling. These knowledge is a prerequisite for the introduction into cell culture technology and principles in tissue engineering. A methodical focus will be on detection of vitality, metabolic activity, histological staining and antibody-based detection methods such as ELISA; RIA, FACS or MACS. In the second half of the course we will focus on (I) the development of (bio)materials as 3D scaffolds and , the (II) bioreactor technology in Tissue Engineering, (III) non-invasive detection methods and (IV) modeling cell material interaction for tissue engineering. Finally, we give a brief insight into the application of human 3D tissues. **Content:** ▪ Fundamentals of cell biology and cell culture technology ▪ Biological methods to characterize cellular function ▪ Basic principles of tissue engineering ▪ 3D tissue models and their application
Literature	review article will be provided
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparing for tutorials and solving homework assignments (56h), preparing for exam (20h), reading additional material (20h)
Frequency	Every winter semester Also offered in the summer semester!
Duration	One semester
Responsible person	Prof. Dr. rer. biol. hum. Heike Walles (Extern)

Introduction into Medical Imaging Technologies

Objectives and content	**Objectives:** ▪ get on overview about modern medical imaging modalities ▪ understand the functional principle of the different technologies ▪ get to know to the most important medical applications of imaging ▪ discuss the pros and cons of the particular modalities ▪ have an overview about some required image processing **Content:** ▪ Radiography ▪ Computed Tomography ▪ Nuclear medicine imaging (PET, SPECT) ▪ Sonography ▪ Magnetic Resonance Imaging
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Basics of Radiation Physics and Image Science
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate ⚠preparation of a short talk
Examination	Written examination 90min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the Exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Introduction to Deep Learning

Objectives and content	**Objectives:** ▪ confidently apply DL techniques to develop a solution for a given problem ▪ follow recent DL publications and critically assess their contributions ▪ formulate hypotheses and design & conduct DL experiments to validate them ▪ document progress & design decisions for reproducibility and transparency **Content:** ▪ artificial neural network fundamentals (gradient descent & backpropagation, activation functions) ▪ network architectures (Convolutional Neural Networks, Recurrent/Recursive Neural Networks, Auto-Encoders) ▪ regularization techniques ▪ introspection & analysis techniques ▪ optimization techniques ▪ advanced training strategies (e.g. teacher-student)
Literature	[1] Ian Goodfellow, Yoshua Bengio & Aaron Courville: „Deep Learning“, MIT Press, 2016
Teaching	Lecture, Tutorial
Prerequisites	Machine learning for Medical Systems, Number of participants limited, Only for students with excellent knowledge in signal processing, mathematics and machine learning
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None ⚠Exam requirements: participation and active involvement in the course and the exercises (defined in the 1st lecture and published on the course website)
Examination	Written examination 120min
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparing for tutorials and solving homework assignments (56h), preparing for exam (20h), reading additional material (20h)
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Sebastian Stober (FIN-IKS)

Introduction to Programming Techniques in Engineering

Objectives and content	**Objectives:** The student will be able to program in Python and Arduino by the end of the course. They will be able to present data in graphical manners, to program interactive graphical user interfaces, and to control Arduino based hardware with software programming. **Content:** ▪ Fundamentals of Python programming ▪ Data manipulation and representation ▪ Scientific calculations ▪ Interactive graphical user interface (GUI) ▪ Arduino programming platform ▪ Arduino hardware development
Literature	Online resources on Python and Arduino
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Seminar Autonomous work: Preparing for tutorials and solving homework assignments (56h), preparing for exam (20h), reading additional material (20h)
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. Siew-Wan Ohl (Forschungscampus STIMULATE)

Machine Learning for Medical Systems

Objectives and content	**Objectives:** The student will ▪ understand the basics of Learning Theory ▪ get an in-depth understanding for problems and concepts in the area of Machine Learning ▪ learn data structures and algorithms of Machine Learning ▪ be enabled to apply these methods to real-world medical data analysis problems **Content:** ▪ Concept Learning and Version Space ▪ Learning Decision Trees ▪ Neural Networks ▪ Bayesian Learning ▪ Instance-based Learning and Cluster Analysis ▪ Association Rule Learning ▪ Reinforcement Learning ▪ Hypothesis Evaluation
Literature	
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Oral examination
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Seminar Autonomous work: Preparation of the lectures and seminars, preparation of the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Andreas Nürnberger (FIN-ITI)

Master Thesis

Objectives and content	**Objectives:** The student will: ▪ Create a research-oriented scientific dissertation ▪ Masters the writing of a scientific report in the extent of a Master thesis ▪ Be able to present his own work and to answer questions scientifically **Content:** According to prior agreement with the supervisor
Literature	
Teaching	None
Prerequisites	See examination regulations
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation ⚠See examination regulations
Credit Points	30 CP = 900 h (0 h time of attendance + 900 h autonomous work)
Work load	Time of attendance: Individual Decision Autonomous work: Individual Decision
Frequency	Every winter semester
Duration	One semester
Responsible person	Examiner of the Master Thesis

Mathematical foundations

Objectives and content	**Objectives:** The student will be able to use basic mathematical tools to study problems in Medical Systems Engineering. After attending the lecture, he/she will also be able to extend their mathematical skills by studying on their own. **Content:** ▪ n-dimensional Euclidean space ▪ Matrix algebra ▪ Solving linear equations ▪ Eigenvalues and -spaces ▪ Simple examples of ordinary differential equations ▪ Functions in several variables ▪ Optimization of functions in several variables
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparing for tutorials and solving homework assignments (40h), preparing for exam (20h), reading lecture notes and additional material (70h)
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Benjamin Nill (FMA-IAG)

Mathematical Modeling of physiological Systems

Objectives and content	**Objectives:** The student will ▪ learn methods for mathematical modeling of physiological systems ▪ from 1st principles based on fundamental physical and chemical relations ▪ learn different methods and tools for computer simulation of physiological ▪ system with application to selected subsystems ▪ gain a fundamental understanding of the dynamics of the considered subsystems by means of targeted simulation experiments ▪ be able to transfer the methodology to other physiological systems in the frame of future research projects **Content:** ▪ cardio vascular system ▪ control of cell volume and electrical properties of cell membranes ▪ signal transduction in nerve cells ▪ signal transduction in the retina ▪ signal transduction in the ear/ ear implants ▪ population balance modelling of cellular systems
Literature	[1] Hoppensteadt, F.C.; Peskin, C.S.:. Modeling and Simulation in Medicine and the Life Sciences, Springer, Berlin, 2002. [2] Keener, J.; Sneyd, J.: Mathematical Physiology, Springer, Berlin, 1998.
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: post processing of lectures and preparation of computer exercises
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Achim Kienle (FEIT-IFAT)

Medical basics for engineering students

Teaching	Seminar
Prerequisites	Mathematics, Physics, Fundamentals in Electrical Engineering, Basic understanding of medical terms
Recommended prerequisites	None
Applicability of the module	Master program
Examination	Seminar presentation
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 4 SWS Seminar
Frequency	Every summer semester
Duration	One semester
Responsible person	

Sub-Module: Anatomy for Engineering students

Objectives and content	**Objectives:** ▪ Basic knowledge of anatomy and physiology of the central and peripheral nervous system ▪ Basic knowledge of anatomy and physiology of the human cardio-vascular system ▪ Basic knowledge of the anatomy and physiology of the human musculoskeletal system ▪ Knowledge about the biomechanical properties of the structures/organs discussed ▪ Knowledge about the resulting consequences and requirements for medical devices and implants **Content:** ▪ The microscopic and macroscopic structure and function of the nervous system, the cardiovascular system and the musculoskeletal system ▪ Main focuses are the biomechanical properties and the functionality of the discussed structures and the links and application in biomedical engineering ▪ Relevant examples are: The elastic properties of blood vessels, haemodynamics, pulsatile flow, rigidity and plasticity of the bones and the kinematics of joints.
Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 3 SWS Seminar Autonomous work: Preparation of the Lectures and Tutorials, Learning of the respective structures and functions
Frequency	Every summer semester
Duration	One semester

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Responsible person	Priv.-Doz. Dr. med. Elisabeth Eppler (Lehrbeauftragte)

Sub-Module: Radiological Diagnostics

Objectives and content	**Objectives:** ▪ Knowledge on the fundamental functions of common medical imaging methods from a medical point of view ▪ Knowledge of the characteristics of human tissues and their visualisation by imaging techniques ▪ Knowledge on the specufic problems of different techniques ▪ Understanding for the role of different techniques ▪ Knowledge on the demand for future medicine **Content:** The functioning of commonly used medical imaging techniques from a medical doctor´s point of view are addressed and related to specific characteristics of human tissues (X-ray density, relaxivity, water content...). Thus, the different imaging of diverse tissues by the respective imaging techniques are explained. The limitations odf the different methodological approaches are demonstrated. Demands for future medical imaging techniques with respect to still unanswered medical issues are addressed.
Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 1 SWS Seminar Autonomous work: Preparation of the Seminars, Learning of the respective structures and functions
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. med. Maciej Pech (FME-ZRAD-KRN)

Medical Measurement Technology

Objectives and content	**Objectives:** The students gain knowledge in fundamentals of chemical and biological sensors and their application in medicine. After finishing the module they will understand modern principles of chemical and biochemical sensors, including signal sources, signal propagation and detection. The students will be able applying chemical and biochemical sensors in hospital practice, point-of-care medicine, ambient assisted living and interdisciplinary science. They will further achieve basic knowledge in the design of sensors and sensor systems. The students gain information on the fundamental concepts and principles of ultrasonic sensors and the characteristics and requirements of ultrasonic sensors for imaging. At the end of the module they are able to engineer ultrasonic sensors and apply the physics behind signal analysis for ultrasonic imaging. They will be able to join interdisciplinary groups working on ultrasonic imaging, develop new sensors and imaging schemes. **Content:** 1. Basics of chemical sensor and systematization 2. Thermodynamics, kinetics, sensitivity and selectivity 3. Electrochemical sensors and ISFETs 4. Catalytic principles 5. Resonant, MEMS, NEMS, MOMS sensors 6. Selected sensor systems applications 7. Principles of generation and detection of ultrasound 8. Fundamentals of acoustic wave propagation 9. Methods of signal optimization and signal extraction 10. New trends in ultrasonic sensor development and imaging principles
Literature	[1] Watson, J., Chemical Sensors 1-6, Momentum Press 2010. [2] Sanches, J.M., Ultrasound Imaging: Advances and Applications, Springer 2012 dx.doi.org/10.1007/978-1-4614-1180-2. [3] Scabo, T.L., Diagnostic Ultrasound Imaging, Elsevier, 2007.
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Seminar Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Ulrike Steinmann (FEIT-IFAT)

Medical Visualization

Objectives and content	**Objectives:** ▪ An understanding of medical diagnosis and treatment with 3D volume data ▪ An understanding of perceptual issues in interpreting medical volume data, presented in 2D and 3D displays ▪ An understanding of user needs in selected diagnostic and treatment planning tasks **Content:** ▪ Introduction to medical image processing and analysis ▪ Surface rendering of medical volume data ▪ Web-based 3D visualization of medical volume data ▪ Volume rendering ▪ Advanced transfer functions ▪ Visualization of vascular structures ▪ Virtual endoscopy ▪ Illustrative medical visualization ▪ Interaction techniques with 3D visualizations of medical volume data ▪ Visual exploration of blood flow data The individual lectures explain algorithms along with specific applications. Diagnosis of (cardio-) vascular diseases and treatment of cancer patients are the key applications discussed in most of the lectures.
Literature	Bernhard Preim, Charl P Botha. Visual Computing for Medicine, Second Edition: Theory, Algorithms, and Applications , Morgan Kaufmann, 2013
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG)

MEMS-Packaging for Medical Solutions

Objectives and content	**Objectives:** The students gain basic knowledge in electronic and MEMS packaging technologies for medical solutions. They learn about materials, processes and technologies for packaging with special attention to medical solution. After finishing the module they will understand the importance of packaging for medical solutions, microelectronics and MEMS. They gain knowledge in packaging methods, thermal management and restrictions for medical solutions. They will be able to select an appropriate packaging solution for a given medical application. By means of exercises they learn to deepen their knowledge for further research and to apply it to solve complex problems. **Content:** ▪ Introduction to electronic and medical electronic packaging ▪ Basic semiconductor packaging ▪ Substrates and their technologies ▪ Packaging for medical devices ▪ Reliability and test ▪ Medical requirements, biocompatibility
Literature	Integrated Circuit Packaging, Assembly and Interconnections ISBN 978-0-387-33913-9; Fundamentals of Microsystems Packaging ISBN 0-07-120301-X, Advanced Electronic Packaging ISBN 0-471-46609-3
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, preparation of exercises, preparation of presentation, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Bertram Schmidt (FEIT-IMOS)

Methods of MRI

Objectives and content	**Objectives:** ▪ Understanding of magnetic resonance principle ▪ Knowledge of spatial encoding in MR ▪ Knowledge of different MR measurement methods ▪ Understanding of MR reconstruction principles ▪ Understanding of physical and technical possibilities and limitations ▪ Ability to apply knowledge for simple modifications of MR sequences **Content:** ▪ MR signal generation ▪ MR signal evolution (Bloch equation) ▪ MR measurement parameters ▪ Spatial encoding ▪ MR measurement methods (sequences) ▪ MR reconstruction
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering, physics or related subjects, Basics of physics, mathematics and imaging systems
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 90min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: recapitulation of courses, preparation of exercises and exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. habil. Oliver Speck (FNW-IEP)

Microfluidics: Theory and Applications

Objectives and content	**Objectives:**
	The student will:
	▪ be trained in basic fluid mechanics and the particularities of flows on microscopic spatial scales
	▪ learn about areas of applications of microfluidics
	▪ obtain solutions from simple numerical techniques
	▪ compare analytical solutions with numerical solutions to experience limits and possibilities of computational fluid mechanics
	Content:
	▪ Basic concepts in microfluidics
	▪ Conservation laws (mass, momentum, energy)
	▪ Simple flows
	  ▫ Hydrostatics
	  ▫ Couette & Poiseuille flows
	  ▫ Stokes Drag
	▪ Microfluidic network analysis (hydraulic resistance and compliance)
	▪ Capillarity
	▪ Electro hydrodynamic
	  ▫ Electroosmosis
	  ▫ Dielectrophoresis
	▪ Selected flows in microfluidics
	▪ Hele-Shaw geometry
	▪ Multiphase flows
	▪ Gas bubbles and droplet
	▪ Acoustofluidics

Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program (Deepening Mechanical- and Flow-Simulation in Medical Engineering)
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Claus-Dieter Ohl (FNW-IEP)

Microsystems- and Nano-Technologies for Medical Solutions

Objectives and content	**Objectives:** The students gain knowledge in fundamentals of microsystems technologies as well as knowledge about medical products by means of MEMS and Nano technologies and future trends. After finishing the module they will understand the production technologies for MEMS- and Nano-devices and will be able applying these technologies for the conceptual development of miniaturized medical components (e.g. micropumps, microvalves, pressure sensors). They will further achieve basic knowledge about the requirements of medical MEMS products like sensors, actuators and microsystems. By means of exercises they learn to deepen their knowledge for further research and to apply it to solve complex problems. **Content:** ▪ MEMS and Nano: definition, technologies, markets ▪ Materials for MEMS and Nanotechnologies ▪ Cleanroom and vacuum techniques ▪ Thin film technologies: PVD, CVD ▪ Lithography: resists, optical lithography, e-beam and x-ray lithography ▪ Etching ▪ Bulk-micromachining, surface-micromachining, LIGA principles, ▪ Selected examples of medical micro- and nanosystems
Literature	Fundamentals of microfabrication: the science of miniaturization; Marc J. Madou. - 2. ed. - Boca Raton: CRC Press, 2002, ISBN: 0-8493-0826-7
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, preparation of exercises, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Bertram Schmidt (FEIT-IMOS)

Modeling and Finite Element Simulation with Partial Differential Equations

Objectives and content	**Objectives:** The student will gain experience in the modelling of physical and technical phenomena with partial differential equations and learn the basics of the finite element method for discretizing such problems. Different processes like diffusion, transport and reaction are discussed. The students will learn the basics of the finite element methods and its application to different types of partial differential equations. **Content:** ▪ Modeling of diffusion, transport and reaction with partial differential equations ▪ Variational formulations ▪ Linear Finite Elements ▪ Solution of linear Systems ▪ Stabilized finite elements for transport problems
Literature	Will be announced
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program (Deepening Computer-Simulation in Medical Engineering)
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparation of the lectures and tutorials, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Thomas Richter (FMA-IAN)

Nuclear medicine

Objectives and content	**Objectives:** The students will learn about the fundamentals of physics and technology used in nuclear medicine. The course will cover the basics of radioactive processes and materials. It will then describe in detail the various applications for diagnostic applications and therapeutic applications, its measurements, specific radiation protection measures and current developments. **Content:** ▪ Introduction - what is nuclear medicine? ▪ The basic elements of matter ▪ The nucleus ▪ Decay processes ▪ Radiation therapy with radioisotopes ▪ Medical imaging with radioisotopes ▪ Tracers ▪ Specific tasks for radiation protection ▪ Prospects
Literature	[1] Radiation Physics for nuclear medicine, Ed. Cantone, Hoeschen [2] Radiation Protection in Nuclear Medicine, Ed. Mattsson, Hoeschen [3] Imaging in Nuclear Medicine, Ed. Giussani, Hoeschen
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min ⚠examination without additional help except a non-programmable calculator
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: recapture lectures, prepare tutorial, prepare exam, prepare short presentation
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Positron Emission Tomography (PET)

Objectives and content	**Objectives:** Positron Emission Tomography (PET) is a non-invasive diagnostic technique allowing to visualize the 3-dimensional distribution of a targeted metabolic process. Students will understand the physical and mathematical fundaments of modern PET and the scientific and technological reason behind novel digital signal and sensor approaches for PET. They will learn to quantify the performance of a PET system on the basis of NEMA standards and to conduct a radiomic quantitative analysis of a PET image. **Content:** ▪ Physical principles of PET ▪ Modern reconstruction algorithms for PET ▪ New CMOS sensors and digital electronics ▪ Physical aspects of NEMA standards ▪ Pre-clinical, clinical, brain and proton therapy monitoring PET systems ▪ Radiomics in PET imaging
Literature	D. L. Bailey, D. W. Townsend, P. E. Valk, M. N. Maidey, Positron Emission Tomography, Springer, 2005.
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial ⚠Verification in class at the beginning of each lecture Autonomous work: Solving homework assignments (48 h), Preparing for lectures (48h), preparing for exam (30h)
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Nicola D'Ascenzo (FEIT)

Research Project

Objectives and content	**Objectives:** With this module, particularly high-performing students will be optimally prepared for their thesis and future research works. After completing the module, students are able to solve complex scientific and engineering problems in the field of medical technology independently and creatively and are able to document their results on a scientifically a high level. **Content:** The students work on current research projects in the field of medical technology. They learn to independently solve challenging research tasks. At least one research assistant of the respective project supervises the students. Depending on the students' interests, the following topics are possible: ▪ Design and development of analog or digital electronic circuits for medical technology (hardware) ▪ Design and development of special algorithms for medical technology (software) ▪ Design of simulators or prototypes (software or hardware) ▪ Development of specific solutions in the field of imaging and image processing (X-ray, CT, MRI, PET, ultrasound)
Literature	Depending on research project
Teaching	None
Prerequisites	Completion of all compulsory modules of the first semester; Proactive personality; Excellent academic performance during bachelor and current master; Detailed proposal and time planning of the research project; Acceptance by the examination board
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Proposal
Examination	Seminar presentation
Credit Points	15 CP = 450 h (0 h time of attendance + 450 h autonomous work)
Work load	Time of attendance in winter semester: Individual decision Time of attendance in summer semester: Individual decision Autonomous work:
Frequency	Starts every winter semester Maximum of 6 students per admission year.
Duration	Two semesters
Responsible person	Examiner of the Research Project

Scientific working

Objectives and content	**Objectives:** The student will: ▪ learn to do literature research ▪ make references and assistance accessible ▪ practice communication within groups ▪ learn to handle his emotions during presentations and discussions ▪ deal with an international audience and an intercultural communication ▪ have to describe and express complex context ▪ practice oral, graphical and written communication ▪ learn how write a proper scientific paper ▪ practice feedback **Content:** The students have to present a recent Paper of a reputable Journal, selected by them. Beside the introduction into the specific topic and the work of the author, the students have to assess the quality of the paper and try to answer back in the final discussion. A mutual assessment of the presentation is part of the seminar. At the end of the seminar the students have to write a paper related written report and take part in the seminar-integrated peer review process.
Literature	
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 4 SWS Seminar Autonomous work: Preparation of the seminars and lab project, preparation of the presentation
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Solution Design in Medical Engineering

Objectives and content	**Objectives:** **Content:**
Literature	
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Seminar presentation
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Seminar Autonomous work: Preparation of the seminars and lab project, preparation of the presentation
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Theoretical Neuroscience I

Objectives and content	**Objectives:** **Content:** Based on Chapters 5-6 and Chapters 1-4 of Dayan & Abbott. Electrochemical equilibrium and Nernst Equation, equivalent circuits for single-compartment model, leaky integrate-and-fire model, Hodgkin-Huxley and Connor-Stevens models of action potential, cable equation and neuron morphology, characterizing neuronal responses with tuning curves and receptive fields, signal-detection theory and psychometric function, comparision of neuronal and behavioural responses with neurometric function, population coding, statistically efficient decoding with maximum likelihood and maximum a posteriori likelihood, Fisher information, introduction to Shannon information, application of Shannon information to neural responses. To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam. The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Sterrat, Graham, et al., "Principles of Computational Modelling in Neuroscience", 2011
Teaching	Lecture
Prerequisites	First degree in physics, mathematics, or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010.
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 180min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture Autonomous work: Preparation of the lectures, preparation of the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Jochen Braun (FNW-IBIO)

Theoretical Neuroscience II

Objectives and content	**Objectives:** **Content:** Based on Chapters 7-10 of Dayan & Abbott. Rate models of network dynamics, synaptic plasticity, reinforcement learning, and generative models. Linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states, models of activity-dependent plasticity, associative learning with neural networks, modern theories of reinforcement learning (Rescorla-Wagner, temporal-difference, actor-critic models), and abstract approaches to representational learning and generative models (expectation maximization, principal components, independent components). To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam. The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Wilson, "Spikes, Decisions, Actions: the Dynamical Foundations of Neuroscience", OUP 1999 [3] Sutton & Barto, "Reinforcement Learning: an Introduction", MIT Press, 1999
Teaching	Lecture
Prerequisites	First degree in physics, mathematics, or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010.
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 180min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture Autonomous work: Preparation of the lectures, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Jochen Braun (FNW-IBIO)

Three Dimensional and Advanced Interaction

Objectives and content	**Objectives:** ▪ Understanding the nature and importance of future user interfaces and the challenges and problems associated with them ▪ Getting to know, analyzing and evaluating technologies, interaction techniques and methods for the development of advanced user interfaces ▪ Ability to select suitable technologies and interaction techniques in the field of three-dimensional and modern Post-WIMP user interfaces ▪ Ability to critically analyze scientific literature and knowledge of scientific publishing ▪ Ability to conduct own research on a postgraduate level in the field of advanced user interfaces **Content:** ▪ Introduction to Post-WIMP and Reality-based User Interfaces3D-Interaction: Tasks, Devices, 3D-Widgets, 3D UIs ▪ Augmented Reality Interaction ▪ Pen-based Interaction Techniques and Sketching ▪ Multitouch: Technologies, Gestures, Applications ▪ Gestural Interaction: Tracking, Freehand Gestures ▪ Tangible Interaction ▪ Advanced Topics: Gaze-based Interaction, Organic Interfaces, Everywhere Interfaces
Literature	[1] Bowman, Kruijff, Laviola, Jr., Poupyrev: „3D User Interfaces: Theory and Practice“, Addison-Wesley, 2004 [2] Müller-Tomfelde (Ed.): „Tabletops - Horizontal Interactive Displays“, Springer, 2010 [3] Saffer: „Designing Gestural Interfaces“, O'Reilly Media, 2008 [4] Shaer, Hornecker: „Tangible User Interfaces: Past, Present and Future Directions“. In Foundations and Trends in Human-Computer Interaction, 3 (1), 2010 [5] Further references during the lecture and on the current website of the module (http://isgwww.cs.uni-magdeburg.de/uise/Studium/WS2010/VorlesungTAI/)
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	Interactive Systems lecture, User Interface Engineering lecture
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Reworking of the lecture, Working on the seminar exercises, Exam preparation
Frequency	Every winter semester Also offered in the winter semester!
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG)

Visual Analytics in Healthcare

Objectives and content	**Objectives:** Learning objectives and competences to be acquired: This seminar teaches how combinations of data analysis (clustering, regression analysis, classification rules) can be combined with methods of interactive visualization, e.g. heat maps, scatter-plots and time-based visualizations to solve problems in healthcare. The applications concern clinical medicine (decision support for physicians based on electronic health records), medical research, e.g. the recognition of undesirable drug effects, the area of public health, which is concerned, for example, with defining an adequate data-based reaction to a strong outbreak of an infectious disease, and epidemiology, which examines risk factors for the development of diseases on the basis of observation and cohort studies and thus develops approaches for the prevention of diseases. All the topics covered are based on real data. The presentations are also intended to raise awareness of the fact that data quality is never perfect; missing and partially unreliable or at least inaccurate data are the basis of the analytical evaluation. **Content:** ▪ Overview: Potential and applications of Visual Analytics in Healthcare ▪ Visual Analytics in Public Health ▪ Visual Analytics in Clinical Medicine ▪ Visual Analytics for Detecting Adverse Drug Effects ▪ Visual Analytics in Epidemiology
Literature	Workshop volumes of the IEEE Workshop Visual Analytics in Healthcare (since 2010), selected publications of other conferences / magazines in the fields of data analysis and visualization
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	Visualization, Data Mining, Visual Analytics or Information Visualization
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
Credit Points	3 CP = 90 h (28 h time of attendance + 62 h autonomous work)
Work load	Time of attendance: 2 SWS Seminar Autonomous work:
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG)