OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG

EIT

FAKULTÄT FÜR ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Module descriptions

Master

Medical Systems Engineering

April 15, 2021

updated February, 2026

Contents

Advanced MR Image Reconstruction

Objectives and content	**Objectives:** The students will: ▪ get knowledge of different image reconstruction problems in MRI ▪ get knowledge of different image reconstruction algorithms in MRI ▪ understand MR image reconstruction as an inverse problem ▪ get knowledge of basic parallel image reconstruction algorithms ▪ get the ability to reproduce (code) simple image reconstruction algorithms **Content:** ▪ Partial Fourier imaging and homodyne reconstruction ▪ Parallel imaging algorithms such as SMASH/SENSE and GRAPPA/SPIRIT ▪ Non-Cartesian imaging strategies such as radial sampling ▪ Key ideas and algorithms of Compressed Sensing reconstruction methods
Literature	
Language	English
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	Methods of MRI (by Prof. Speck) or MRI Pulse Sequence Design (by Dr. Röll)
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: recapitulation of courses, preparation of exercises and exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. rer. nat. Volkert Roeloffs (Neoscan Solutions GmbH)

Advanced PCB Design

Objectives and content	**Objectives:** In the lecture and practical exercises, students acquire both the theoretical and practical knowledge necessary to develop and subsequently implement electrical circuits or systems on printed circuit boards. The topics range from the initial conceptualization and selection of components/materials, through the correct placement and connection of components, to strategies for error detection and correction in the actual manufactured system. The content of the lecture is always complemented by the practical exercises in the design of an actual printed circuit board, from inception to manufacturing. **Content:** ▪ Fundamentals ▪ System Layout ▪ Printed Circuit Boards and Materials ▪ Layout Considerations ▪ System Design ▪ Application Specific Implementations methods
Literature	
Language	English
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	Fundamentals of Electrical Engineering (or comparable) and Electronic circuit technology (or comparable)
Applicability of the module	Master program
Prerequisite for the admission to any examination	Participation in the tutorial
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, 1 SWS Tutorial Autonomous work: recapitulation of the lecture, Solving exercises/project tasks and preparing for the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Fabian Lurz (FEIT-IIKT)

Advances in Radiation and Medical Physics

Objectives and content	**Objectives:** The term "Medical Physics" includes especially clinical work and responsibilities. It contains many different areas such as Radiation Protection in official institutions, maintenance of all parts/devices/machines that produce ionizing radiation as well as radiation treatment planning and monitoring. With regards to this broad subject, the course covers standard and advanced methods in the following main topics. **Content:** 1. Refreshing Medical Physics and radiation protection 2. Dosimetry 3. Numerical dosimetry - Biokinetics 4. Numerical dosimetry - MonteCarlo Simulations 5. Radiation Therapy Monitoring 6. HIFU therapy 7. Breath gas analysis 8. Audiology Summary / new directions in medical physics e.g. AI applications
Literature	[1] The 2007 recommendations of the ICRP, ICRP 103 (2007) [2] Caner, Radiation Protection in Medical Physics (2010) [3] ICRP computational framework for internal dose assessment (2015) [4] Vassiliev, Monte Carlo Methods for Radiation Transport (2017) [5] Wong, Advanced and Emerging Technologies in Oncology (2018) [6] Podgorsak, Radiation Physics for Medical Physicists (2016)
Language	English
Teaching	Lecture, Tutorial, Lab Project
Prerequisites	None
Recommended prerequisites	Fundamental courses in programming and dosimetry
Applicability of the module	Master program
Prerequisite for the admission to any examination	Lab certificate
Examination	Written examination 120 min
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	Every winter semester
Duration	Two semesters
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Analog and Mixed-Signal Systems

<table>
<tr><td>Objectives and content</td><td>

Objectives:

This module provides students with both fundamental and application-oriented knowledge in the design and analysis of analog and mixed-signal electronic systems. A particular emphasis is placed on the understanding and characterization of noise and nonlinearities in analog circuits, including the classification of underlying physical noise mechanisms. Students will acquire skills to design frequency-conversion systems, develop frequency and level plans, and analyze the behavior of oscillators and phase-locked loops (PLLs). They will learn to analyze amplifiers down to the transistor level and assess complex analog circuits in both large- and small-signal operations using analytical and simulation-based methods. Measurement setups for the characterization of distortion and noise are covered, along with practical filter implementations and frequencyâ€‘domain characterization using analytical and simulation-based methods. In addition, students gain insight into the architecture, functions and performance metrics of analog-to-digital (ADC) and digital-to-analog converters (DACs) as key interfaces bridging the analog and digital domains. The competencies acquired in this module are essential for the development of advanced medical systems. They enable the design of low-noise and low-power front ends for physiological signal acquisition (e.g., ECG, EEG, EMG), the implementation of high dynamic range RF receive chains in MRI systems, and the realization of mixed-signal electronics in ultrasound imaging, endoscopy, and therapeutic equipment.

Content:

- Nonlinearities and distortion in analog systems
- Filter design and implementation
- Intrinsic noise concepts and physical noise sources
- Noise parameters and two-port characterization
- Design and analysis of small-signal and power amplifiers
- Mixers and frequency conversion techniques
- Oscillator circuits and behavior
- Phase-locked loops (PLLs) and synthesis concepts
- ADC and DAC architectures, methods, and performance metrics

</td></tr>
<tr><td>Literature</td><td>

- B. Razavi, RF Microelectronics, 2nd ed. Upper Saddle River, NJ: Prentice Hall
- P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, 3rd ed. New York, NY: Oxford Univ. Press
- R. B. Northrop, Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation, 2nd ed. Boca Raton, FL: CRC Press

</td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Teaching</td><td>Lecture, Exercise</td></tr>
<tr><td>Prerequisites</td><td>Fundamentals of Electrical Engineering (or comparable), Electronics and Information Technology (or comparable), Signals and systems (or comparable)</td></tr>
<tr><td>Recommended prerequisites</td><td>None</td></tr>
<tr><td>Applicability of the module</td><td>Master program</td></tr>
<tr><td>Prerequisite for the admission to any examination</td><td>None</td></tr>
<tr><td>Examination</td><td>Written examination 90min</td></tr>
<tr><td>Credit Points</td><td>5 CP = 150 h (56 h time of attendance + 94 h autonomous work)</td></tr>
</table>

(continued on the next page)

(continued)

Work load	Time of attendance: 2 SWS Lecture, 2 SWS Exercise Autonomous work: Reviewing the lecture, solving exercises/project tasks and preparing for the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Fabian Lurz (FEIT-IIKT)

Anatomy for Engineering Students

Objectives and content	**Objectives:** ▪ Students acquire basic knowledge of anatomy and physiology of the central and peripheral nervous system ▪ Students acquire basic knowledge of anatomy and physiology of the locomotion system ▪ Students acquire basic knowledge of anatomy and physiology of the cardiovascular system ▪ Students acquire basic understanding of the human metabolic organs ▪ Students apply knowledge on biomechanical properties of the structures/organs discussed in a problem-based approach ▪ Students apply knowledge on consequences and requirements for medical devices and implants in a problem-based approach **Content:** ▪ Microscopic and macroscopic structures and functions of human nervous system, musculoskeletal system, cardiovascular system, and metabolic systems (digestive tract, excretory tracts, hormonal regulation) ▪ Literature search on biomechanical properties and functionality of the discussed structures, and application in biomedical engineering ▪ Team-work of presentations, e.g., on elastic properties of blood vessels, haemodynamics, pulsatile flow, electrophysiology of the heart, kinematics of joints, endoscopic devices, minimal invasive diagnostics and therapies
Literature	Anatomy and Physiology books and atlases, original research articles, reviews, PubMed, open E-learning sources
Language	English
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 (42 h time of attendance + 78 h autonomous work)
Work load	Time of attendance: 3 SWS Seminar Autonomous work: Preparation of the Team-Lectures and Tutorials, Problem-based learning of respective structures and functions, E-Learning
Frequency	Every summer semester
Duration	One semester
Responsible person	Priv.-Doz. Dr. med. Elisabeth Eppler (Research Campus *STIMULATE*, Magdeburger Arbeitsgemeinschaft für Forschung unter Weltraum- und Schwerelosigkeitsbedingungen MARS, University of Magdeburg, Institute of Anatomy, University of Bern)

Applications of Microsystems in Medical Engineering

Objectives and content	**Objectives:** This seminar explores the fundamental principles and advanced applications of microsystems in modern medical engineering, focusing on their integration, implementation, and impact on healthcare technologies. The student will: ▪ Develop comprehensive understanding of microsystem applications in medical engineering ▪ Analyze current technological advances in medical microsystems and their clinical applications ▪ Evaluate the implementation challenges and solutions for medical microsystem technologies ▪ Explore the integration of microsystems in various medical devices and diagnostic tools ▪ Gain research experience through literature review and presentation of selected topics in medical microsystems **Content:** Students will work with assigned research papers of their interest to develop in-depth knowledge of specific applications and present their findings. The seminar consists of three mandatory sessions: an initial meeting for topic selection and methodology guidance, a progress discussion meeting for reviewing preliminary findings, and final presentations where students present their complete research based on assigned papers. The length of the presentations ranging from 30 to 90 minutes and expected volume of the literature will be adjusted to the number of participants to balance the overall workload (more participants = smaller volume, more classroom time). ▪ Lab-on-a-Chip Technologies for Point-of-Care Diagnostics ▪ Microfluidic Systems for Drug Delivery Applications ▪ MEMS-based Implantable Medical Devices ▪ Microsystem Technologies in Minimally Invasive Surgery ▪ Micro-fabrication Techniques for Medical Device Manufacturing ▪ Integration of Microactuators in Medical Instruments ▪ Microscale Tissue Engineering and Organ-on-Chip Platforms ▪ Smart Materials and Shape Memory Alloys in Medical Microsystems
Literature	
Language	English
Teaching	Seminar, if there is a low number of participants that does not provide for regular seminars, the format can be changed and multiple topics can be assigned
Prerequisites	Completion of at least one of the following modules is highly advised: Micro optics, Micromechanics, Microsystems Processes and Technologies
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	2/3 presentation, 1/3 written exam (60 minutes)
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: Literature research, self-study of related topics, presentation preparation
Frequency	Every summer semester
Duration	One semester

(continued on the next page)

(continued)

Responsible person	Prof. Dr. Matthias Wapler (FEIT-IMT)), Dr. Zeinab Heidary (FEIT-IMT)

Applied Biomechanics

Objectives and content	**Objectives:** ▪ Detailed knowledge concerning deformation mechanisms in solid materials ▪ Understanding to formulate concrete boundary and initial value problems out of continuum mechanics ▪ Detailed knowledge concerning kinematics and kinetics of motion ▪ Knowledge concerning different solution methods for static and dynamical systems ▪ Comprehensive understanding concerning vibration problems in biomechanical systems ▪ Understanding of the general spatial dynamics of rigid biomechanical systems **Content:** ▪ Fundamentals of continuum mechanics ▪ Fundamental balance laws ▪ Constitutive equations for soft (e.g. tissue) and hard (e.g. bone) materials ▪ Kinematics and kinetics of linear and angular motion ▪ Force and energy based mechanical methods for describing dynamical systems ▪ Basics of vibration dynamics (oscillator with 1 and 2 degrees of freedom) ▪ Introduction of harmonic, modal and transient analyses ▪ Coordinate systems and spatial orientation ▪ Basics of spatial dynamics with focus on gyroscopic effects
Literature	
Language	English
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	Knowledge of engineering mechanics (statics, basics of strength theory and dynamics)
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: Individual semester assignment that is included in the examination grade
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Daniel Juhre (FMB-IFME), Jun.-Prof. Dr.-Ing. Elmar Woschke (FMB-IFME), apl. Prof. Dr.-Ing. habil. Konstantin Naumenko (FMB-IFME)

Applied Microfluidics (Microfluidics 2)

Objectives and content	**Objectives:** Students are able to apply the practical fundamentals of microfluidics for the development and implementation of microfluidic experiments. Students recognize the optimal design of microfluidic cells, for example, for processing complex fluids. To this end, all process steps of combined photo and soft lithography as well as additive manufacturing have been worked through together using numerous examples. Students are able to apply the practical fundamentals of microfluidics for the development and implementation of microfluidic experiments. Students recognize the optimal design of microfluidic cells, for example, to process complex fluids. To this end, all process steps of combined photo and soft lithography as well as additive manufacturing have been worked through together using numerous examples. Students have acquired comprehensive skills in developing and successfully using microfluidic systems for materials research, analytics, sensor technology, and biology (biotechnology, cell biology, synthetic biology). **Content:** ▪ Brief theoretical background on microfluidics (complex fluids, (bio)polymer solutions, diffusion, wetting, simulation approaches) ▪ Emulsions and continuous flows ▪ Focus areas: Microfluidics-based materials research, cell cultures, enzymatic reactions, synthetic biology ▪ Conducting microfluidics experiments (preparations, materials, equipment, experimental approaches, troubleshooting)
Literature	
Language	English
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	For a more in-depth look at fluid mechanics in microfluidics, we recommend the corresponding lecture Microfluidics 1 (Prof. Ohl) in the summer semester.
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (48 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Seminar
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Julian Thiele (FVST-ICH)

Applied microsystems engineering innovation laboratory

Objectives and content	**Objectives:** The aim of this module is to implement a new innovation in form of a (highly simplified) start-up up to the level of a product demonstrator. The product should be based in its working principle on MEMS components such as MEMS sensors. By completing the module, the students will have gained experience in the complex project coordination and realization of a technological start-up company, and in implementing advanced applications of MEMS components. **Content:** Prospective students should keep in mind that this is a serious course involving a substantial work load, despite the seemingly short/brief written and oral presentation. The module is designed analogous to the conditions of participation in the VDE COSIMA student competition https://www.cosima-mems.de/ and will be graded similar to the evaluation criteria of the competition. The students work together in groups with up to 4 members and implement their innovative product idea in a simulated start-up project. The group decides upon its internal distribution of duties, the only condition is that it needs to name a speaker. The result of the work is a working demonstrator, some form of marketing (such as social media or a website), a written project portfolio (up to 15 pages including content, team presentation, images, references and appendices) and a pitch presentation (up to 10 minutes). This contains: Product idea, market analysis: ▪ Product demand and target customer groups ▪ Realizability of the business plan ▪ Economic viability Innovation: ▪ Creativity and originality; novelty of the idea. ▪ Technological progress. Does the project use new technologies? ▪ Long-term potential: Can the innovation influence future trends and markets? Implementation of the demonstrator: ▪ Functionality. Does the demonstrator work and demonstrate the core idea? ▪ Technological implementation. Is the implementation robust and thought-through? ▪ Design and user friendliness External communication: ▪ Own internet and social media presentation ▪ (Press communication)* ▪ (Funding: How was the project funded? Which sponsors could be gained?)* Presentation: ▪ Structure and clarity ▪ Visual presentation. (How) is the functioning of the demonstrator presented? Which supporting media are used? ▪ Persuasiveness. Can the team motivate others from their idea? Can they competently answer questions? In addition to the presentation pitch the students should prepare a joint one-page document outlining the individual contributions of the team members. * Additional criteria of the COSIMA competition
Literature	

(continued on the next page)

(continued)

Language	English
Teaching	Independent project work in the laboratory
Prerequisites	None
Recommended prerequisites	The students should decide on their own, whether they feel qualified.
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Presentation consisting of the joint project portfolio and presentation pitch with question-answer session. In addition to the presentation pitch the students should prepare a joint one-page document outlining the individual contributions of the team members. Bachelor and master students of joint projects will be evaluated according to their academic level.
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work))
Work load	Time of attendance: 4 SWS Project work in the laboratory Autonomous work: Project organization and implementation
Frequency	Flexible. The project is conducted usually during the summer semester. Interested students should contact Prof. Wapler well in advance.
Duration	One semester
Responsible person	Prof. Dr. Matthias Wapler (FEIT-IMT)), Dr.-Ing. Holger Bolze (FEIT-IMT)

Basics of Medical Image Science

Objectives and content	**Objectives:** The student will: ▪ get an overview about radiation principles including types of ionizing radiation and their behaviour ▪ learn about the difference between active and passive imaging methods and examples from medical imaging techniques ▪ get to know system theory of 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 ▪ MTF, NPS and DQE ▪ Ideal observer, human observer models, ROC curves
Literature	provided by e-learning system
Language	English
Teaching	Lecture, Exercise
Prerequisites	None
Recommended prerequisites	Mathematics, Physics, Fundamentals in Electrical Engineering
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90 min
Credit Points	5 CP = 120 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Exercise Autonomous work: Rework of lectures and exercises, preparation of exercises
Frequency	Every summer semester *(starting from summer term 2022)*
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

Biomechanical Sensors

Objectives and content	**Objectives:** Sensors in biomechanics have changed and expanded the possibilities of biomechanical analysis. High-precision sensing and feedback systems are essential in medicine, sports, research, and robotics applications, and will continue to revolutionize biomechanics in the future. Increasing advances in sensor performance are leading to a steady convergence towards practical requirements. This lecture will highlight the fundamentals and advances in the development and application of biomechanical sensors at the component level and in (wearable) biomechanical systems. Students will learn the technological fundamentals of sensor systems and discuss their applicability in various application scenarios. In addition, students independently acquire an in-depth knowledge of selected biomechanical issues based on current scientific publications. After successful completion of the module, students will be able to understand and apply measurement principles with different sensors and systems. In the exercises, students are enabled to deepen their knowledge and skills, to communicate and to apply them to concrete problems. **Content:** ▪ tactile sensors ▪ inertial measurement unit (IMU) sensors ▪ pressure sensors ▪ optical sensors ▪ textile-based sensors ▪ smartphone-based sensors for health monitoring and diagnosis
Literature	
Language	English
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Attending of Exercises
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: Post processing of lectures, reading of selected scientific papers and preparation for discussion in tutorial, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Ulrike Steinmann (FEIT-IFAT)

Bioprocess control

Objectives and content	**Objectives:**
	▪ Theoretical and practical knowledge about controllers in fermentation and physiological processes
	▪ Knowledge about different fermentation modes based on industrially relevant examples
	▪ Self-dependent work on a control task from the fermentation field, e.g., pH control
	▪ Deepening in Arduino-based programming
	▪ Advanced understanding of the identification and validation of kinetic models
	Content:
	▪ Introduction
	  ▫ Basic control theory terms
	  ▫ Basics of bioprocess engineering
	  ▫ Common control task in biomedical/physiological systems
	▪ Mathematical modelling approaches
	▪ Regulatory control task in fermentation systems
	▪ Control of a continuous biochemical reactor
	▪ Batch/ Fed-Batch control
	▪ Control of a physiological system: depth of anaesthesia
	▪ Soft sensor development
	▪ Innovative control concepts for microbial fermentations

Literature	▪ Bequette, B.W. (2023). Process Control - Modeling, design, and simulation. ISBN: 978-0-13-403375-4 ▪ Schuegerl, K.; Bellgardt, K.-H. (2000). Bioreactor Engineering: Modeling and Control. ISBN: 978-3-642-59735-0 ▪ Alkhalifa, S. (2022). Machine Learning in Biotechnology and Life Sciences: Build machine learning models using Python and deploy them on the cloud. ISBN: 978-1801811910 ▪ Ogunnaike, B., A.; Ray, W., H. (1994). Process dynamics, modelling and control. ISBN: 0-19-509119-1 ▪ D. Seborg, D. Mellichamp, and T. Edgar (2011). Process Dynamics and Control. ISBN: 9780470646106 ▪ H.-J. Rehm; G. Reed (1993). Biotechnology: Bioprocessing. ISBN: 9783527620845 ▪ Hacisalihazade, S. (2013). Biomedical Applications of Control Engineering. ISBN: 978-3-642-37279-7
Language	English
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	Basic knowledge in bioprocess engineering, Programming knowledge in Python, MATLAB or similar
Applicability of the module	Master program
Prerequisite for the admission to any examination	one passed assignments, attendance at three Q&A sessions
Examination	Written and practical examination, homework assignments
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Seminar, 1 SWS online Q&A

(continued on the next page)

(continued)

Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr.-Ing. Stefanie Duvigneau (FEIT-IFAT)

Clinical Aspects in Imaging and Radiology Therapy

Objectives and content	**Objectives:**
	- Knowledge on the fundamental functions and applications of common medical imaging methods and radiation therapy from a medical point of view
	- Knowledge of the characteristics of human tissues and their visualisation by imaging techniques
	- Understanding for the effects of radiation to human tissues
	- Knowledge of applications of radiation therapy
	- Knowledge on the specific problems of different imaging modalities
	- Understanding for the role of different imaging techniques
	- Knowledge on the demand for future medicine in imaging and radiation
	
	Content:
	- Radiology
	  ◦ Clinical Application of X-Ray and Computed Tomography
	  ◦ Clinical Application of MRI and Sonography
	  ◦ Image-Guided Vascular and Oncological Interventions
	  ◦ Fluoroscopy and Mammography
	- Neuroradiology
	  ◦ Anatomical Basics in Neuroradiology
	  ◦ Neuroradiological Medical Engineering: The Nuts and Bolts
	  ◦ Applied Medical Engineering: How YOU save human lives
	  ◦ Everything you always wanted to know but Were afraid to ask
	- Nuclear Medicine
	  ◦ Conventional Nuclear Medicine, technical basics and applications
	  ◦ PET/CT, technical basics, applications and â€žNew horizonsâ€œ
	  ◦ Nuclear Medicine Therapy
	- Radiation Therapy
	  ◦ Modern image acquisition technique for radiotherapy â€“ from CT to image guided radiotherapy
	  ◦ Linear accelerator technique â€“ the backbone of the radiotherapy
	  ◦ The physician-physicist treatment planning chain in percutaneous radiotherapy: from indication to beam delivery
	  ◦ Stereotactic radiotherapy: high precision radiotherapy and its challenges

Literature	
Language	English
Teaching	Lecture
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written Examination 90 min
Credit Points	5 CP = 150 h (28 h time of attendance + 122 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture Autonomous work: Rework of lectures, examination preparation
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. med. Brunner (FME), Prof. Dr. med, Kreißl (FME), Prof. Dr. med. Mpotsaris (FME), Prof. Dr. med. Pech (FME)

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	
Language	English
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 semesters
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
Language	English
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 semester
Duration	One semesters

(continued on the next page)

(continued)

Responsible person	apl. Prof. Dr.-Ing. habil. Gabor Janiga (FVST - LSS)

Computed Tomography I - Methods on CT

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 their interaction with matter. 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 Cone beam ▪ Implementation ▪ Artefacts and Adjustment
Literature	Kak, Slaney: Principles of computerized tomographic imaging; Kalender: Computed Tomography
Language	English
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 60 min
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: Rework of lectures and tutorial, preparation of exercises
Frequency	Every winter semester
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Computed Tomography II

Teaching	Lecture, Lab project
Prerequisites	Understanding of the functional principle of computed tomography and CT image reconstruction basics Lab course: Basic programming skills (MATLAB or C/C++)
Recommended prerequisites	Computed Tomography I
Applicability of the module	Master program
Examination	Written examination 60 min
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 Lab project
Frequency	Every summer semester
Duration	One semesters
Responsible person	Dr.-Ing. Tim Pfeiffer (FEIT-IMT)

Submodule: Advanced Topics in CT

Objectives and content	**Objectives:**
	The student will:
	▪ get an overview over a variety of specialized CT routines and their (medical) applications
	▪ understand the principles of more sophisticated CT image reconstruction and artifact reduction techniques
	▪ learn how simulated data can be used to investigate problems
	Content:
	The lecture introduces advanced topics in the field of computed tomography (CT). A variety of different aspects and medical applications of specialized CT routines will be presented, covering the following topics:
	▪ Simulation of computed tomography scans
	▪ Advanced Image Reconstruction
	  ▫ Alternative trajectories
	  ▫ Statistical reconstruction
	  ▫ Volume-of-interest imaging
	  ▫ Dynamic imaging (Perfusion)
	▪ Artifact correction methods (beam-hardening, scatter, metal artifacts)
	▪ Spectral CT and Dual energy CT
	▪ Tomosynthesis
	▪ Data consistency conditions
	▪ Biological effects of ionizing radiation and dose reduction techniques
	▪ Phase contrast CT
	▪ 2D/3D image registration

Literature	Kak, Slaney: Principles of computerized tomographic imaging Heismann, Schmidt, Flohr: Spectral computed tomography
Language	English
Teaching	Lecture
Prerequisite for the admission to any examination	None

(continued on the next page)

(continued)

Work load	Time of attendance: 2 SWS Lecture Autonomous work: Rework of lectures
Frequency	Every summer semester
Duration	One semesters
Responsible person	Dr.-Ing. Tim Pfeiffer (FEIT-IMT))

Sub-Module: Lab course CT

Objectives and content	**Objectives:** The student will: ▪ apply theoretical knowledge about computed tomography topics (e.g. from the module "Medical Imaging - Computed Tomography I") ▪ 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 **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
Language	English
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 ▪ 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 autonomous work
Frequency	Every summer semester
Duration	One semesters
Responsible person	Dr.-Ing. Tim Pfeiffer (FEIT-IMT))

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 computerassisted 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	
Language	English
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	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance in winter semester: 2 SWS Lecture, 2 SWS Seminar Autonomous work: Preparation of the lectures and seminars
Frequency	Every winter semester
Duration	One semesters
Responsible person	Prof. Dr. Christian Hansen (FIN-ISG)

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	
Language	English
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 120 min
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 semesters
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	
Language	English
Teaching	Seminar
Prerequisites	Credits obtained in the Course "Digital Signal Processing" (Wendemuth)
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 (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 semesters
Responsible person	Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)

Electromagnetic Compatibility

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 the EMC of electric and electronic systems. They will also be able to analyze the EMC of electrical systems. **Content:** ▪ Introduction ▪ EMC regulation ▪ EM coupling, shielding, filtering ▪ EMC analysis ▪ Interference models for special applications ▪ EMC measures in electronic circuits ▪ Measurement techniques
Literature	K.-H. Gonschoreck, R. Vick: Electromagnetic Compatibility for Device Design and System Integration. Springer Verlag
Language	English
Teaching	Lecture, Exercise
Prerequisites	None
Recommended prerequisites	Bachelor in Electrical Engineering or related studies
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written exam 90 minutes
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 Exercise Autonomous work: Post processing of lectures and laboratory work, preparation of exercises, laboratory work, research report and exam
Frequency	Every summer 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	
Language	English
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	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: Postprocessing of lectures, preparation of exercises and exam
Frequency	Every summer semester
Duration	One semesters
Responsible person	Jun.-Prof. Dr.-Ing. Daniel Juhre (FMB-IFME)

Heterogeneous Computing

Objectives and content	**Objectives:** After successfully completing the module, students will be able to discuss the computing principles of different hardware platforms and select a suitable computing principle for a given application. They can create applications that can be implemented on different hardware platforms and exploit their individual properties. Students can also transform algorithms in such a way that they make optimal use of the possibilities of a given hardware. The students can analyze the data flow within neural networks and adapt hardware architectures to their specifics. Through theoretical and practical exercises, students will be able to deepen their knowledge and skills in a research-oriented manner. Students will realize algorithms in OpenCL for GPUs and CPUs as well as gain practical experience in creating data flow descriptions for FPGA hardware accelerators. **Content:** ▪ Alternative computing principles ▪ Design of hybrid computing systems ▪ Dataflow computing ▪ Introduction to OpenCL ▪ Hardware based OpenCL programming for GPUs, FPGAs, and CPUs ▪ Hardware architecture of GPUs ▪ Introduction to Deep Neural Networks (DNN) ▪ Hardware accelerators for DNNs ▪ Hardware architecture of TPUs
Literature	
Language	English
Teaching	Lecture, Exercise
Prerequisites	None
Recommended prerequisites	Bachelor in electrical engineering or computer science, basic knowledge in C and C++
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral test at the end of the module
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 Excercise Autonomous work: Post processing of lectures, solving of exercises and preparation of exam
Frequency	Every summer semester
Duration	One semesters
Responsible person	Prof. Dr.-Ing. Thilo Pionteck (FEIT-IIKT)

Hybrid Imaging

Objectives and content	**Objectives:** ▪ Understanding for the fundamental principles and limitations of hybrid imaging ▪ Knowledge of the main applications and advantages compared to single modalities ▪ Knowledge of the characteristics of human tissues and their visualisation by imaging techniques ▪ Knowledge on the specific problems of combined modalities ▪ Understanding for the role of combined vs. individual imaging techniques **Content:** ▪ The clinical motivation for hybrid imaging ▪ Basic principles of the hybrid concepts ▪ The history of origin, first prototypes and the methodological and technical development of the individual modalities ▪ The methodological limitations of the individual methods used (e.g. SPECT and PET) and how these can be compensated for by auxiliary imaging (here e.g. CT) ▪ Existing methodological and technical limitations of hybrid imaging (e.g. due to the interaction of the individual modalities / measuring principles e.g. MR and PET, error propagation in the context of image data reconstruction, etc.) ▪ The indication-related optimization of the hybrid imaging and the methods used here for optimization considering the medical indication (including the limits for protocol optimization) ▪ Compliance with the principles of radiation protection when applying and optimizing the methods. ▪ The development of imaging artifacts and their systematic influence on hybrid imaging. ▪ New detector technologies and their methodological developments. ▪ New (potential) hybrid imaging concepts (e.g. US in combination with CT), basic ideas and potential developments
Literature	
Language	English
Teaching	Lecture and Seminar
Prerequisites	None
Recommended prerequisites	Basic knowledge on CT, MRI and PET
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
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 Seminar Autonomous work: Rework of lectures and tutorial, preparation for the seminar presentation
Frequency	Every winter semester
Duration	One semester
Responsible person	Dr. rer. nat. Oliver Großer, M.A. (Executive Medical Physicist) (FME-Department of Radiology and Nuclear Medicine)

Image Coding

Objectives and content	**Objectives:** The objective is to learn the fundamental methods and techniques of image coding as a crucial task in image communication. Image acquisition problems are explained insofar as they are relevant to image coding. Starting from signal/information-theoretical methods, the increasingly significant content-oriented (semantic) techniques are discussed, and applications are explored. Students are enabled to evaluate existing coding methods for still and moving images. They understand relevant problems of image acquisition and representation, know how to estimate the information content of images, master the principles of developing encoders for image and video compression, and are able to apply them in various fields including Medical Imaging. **Content:** ▪ Representation of pictures ▪ Human perception ▪ Image Acquisition ▪ Information theory ▪ Quantization ▪ Data compression ▪ Lossy coding ▪ Video coding ▪ Transform coding ▪ Content based and semantic coding ▪ Standards and applications
Literature	While there is a wealth of literature available on image and video compression, such as John W. Woodsâ€™ â€™Multidimensional Signal, Image, and Video Processing and Codingâ€™ (Academic Press, 2012, online), class attendance remains essential. Materials is provided through the e-learning.
Language	English
Teaching	Lecture, Exercise
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 Exercise 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)

Integrating AI and Medical Imaging: Foundations to Frontiers in Deep Learning

Objectives and content	**Objectives:** This course is designed to provide a comprehensive, interdisciplinary foundation that prepares students to tackle the challenges at the intersection of medical imaging and machine learning. By the end of the course, students will have acquired not only technical skills in handling and processing medical imaging data, but also the ability to develop and apply advanced machine learning techniques in this important field. The aim of this course is to provide a unique blend of skills that will prepare students for working on research projects, master's theses or a future career in the interdisciplinary field of machine learning and medical imaging. Students will not only learn how to handle medical imaging data and apply standard deep learning techniques to medical imaging tasks, but they will also learn how to perform a literature search to find the state of the art for their task, how to evaluate/compare them and select the most appropriate technique for their task. In addition, they learn how to modify the state of the art to improve the shortcomings of these techniques - to develop new ideas. At level 7, students' examinations will cover the topics and projects covered in the lectures as well as additional self-study of the various state-of-the-art techniques (guidance will be given in the lectures). **Content:** Introduction to machine learning (including deep learning) with a focus on image processing, Introduction to medical imaging (MRI and CT) physics and data handling, hands-on projects involving supervised learning tasks (Tumour grade classification, Vessel segmentation, Undersampled image reconstruction and improvement of image quality - MRI and CT) and unsupervised learning tasks (Disease detection in images with the means of anomaly detection, Unsupervised phenotypic discovery directly from images), introduced to cutting-edge deep learning techniques (Transformers, Diffusion Models, Physics-Driven Deep Learning, Federated Learning for Privacy-Preserving Image Analysis, Explainable AI).
Literature	
Language	English
Teaching	Block seminar
Prerequisites	
Recommended prerequisites	Interest in the application of machine learning in medical imaging. Programming skills, basic knowledge of statistics, linear algebra and computer science are required. One or more courses should have been completed: Data Mining, Machine Learning, Deep Learning, Image processing, Fundamentals of Statistics and Linear Algebra.
Applicability of the module	Master program
Prerequisite for the admission to any examination	Completion of the practical projects
Examination	Oral examination
Credit Points	5 CP = 150 h (40 h time of attendance + 110 h autonomous work)
Work load	Time of attendance: 4 SWS Seminar (A block lecture series, 8 hours per day for one week (5 days). This includes theoretical lectures and practical projects with programming tasks. Autonomous work: Follow-up study at home, literature review and overview for exam preparation
Frequency	Every winter semester
Duration	One semester

(continued on the next page)

(continued)

Responsible person	Dr. Soumick Chatterjee (FIN-ITI)

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
Language	English
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 90 min
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, preparing for exam, reading additional material
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. biol. hum. Heike Walles (Prof. Dr. rer. biol. Heike Walles (FVST - ICH)

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 and conduct DL experiments to validate them ▪ document progress and design decisions for reproducibility and transparency ▪ for Master: advanced competencies in scientifical research in topics of the module **Content:** ▪ artificial neural network fundamentals (gradient descent and backpropagation, activation functions) ▪ network architectures (Convolutional Neural Networks, Recurrent/Recursive Neural Networks, Auto-Encoders) ▪ regularization techniques ▪ introspection and analysis techniques ▪ optimization techniques ▪ advanced training strategies (e.g. teacher-student)
Literature	Ian Goodfellow, Yoshua Bengio and Aaron Courville: "Deep Learning", MIT Press, 2016
Language	English
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	▪ linear algebra and probability theory ▪ machine learning (e.g. "Intelligente Systeme" or "Machine Learning")
Applicability of the module	Master program
Prerequisite for the admission to any examination	Participation and active involvement in the course and the exercises (defined in the 1st lecture and published on the course website)
Examination	Written examination 120 min
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 Exercise)
Frequency	Every summer 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
Language	English
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 90 min
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, preparing for exam, reading additional material
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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	
Language	English
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
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: 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 ▪ Master the writing of a scientific report in the extent of a Master thesis with high scientific standard ▪ be able to defend and present her/his own work and to answer questions scientifically **Content:** according to prior agreement with the examiner(s)
Literature	
Language	English, German
Teaching	None
Prerequisites	See Study and Examination Regulations
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written thesis and thesis defence
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	Individual
Duration	One semester
Responsible person	Examiner(s) 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	
Language	English
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, preparing for exam , reading lecture notes and additional material
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.
Language	English
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 Measurement Technology

Objectives and content	**Objectives:** The lecture addresses two main topics: The students acquire knowledge of the fundamentals of **chemical and biological sensors** and their application in medicine. Upon completion of the module, they will understand modern principles of chemical and biochemical sensors, including signal sources, signal propagation, and detection. Students will be able to apply chemical and biochemical sensors in hospital practice, point-of-care medicine, ambient assisted living, and interdisciplinary science. Furthermore, they will gain basic knowledge in the design of sensors and sensor systems. Students will also learn the basic concepts and principles of **ultrasonic sensors**, as well as the characteristics and requirements of ultrasonic sensors for imaging. By the end of the module, they will be able to design ultrasonic sensors and apply the physics behind signal analysis for ultrasonic imaging. They will be able to join interdisciplinary groups working on ultrasound imaging and develop new sensors and imaging techniques. **Content:** **Chemical and biological sensors** ▪ Introduction ▪ Transduction Phenomena ▪ (Bio-)Chemical Sensor Characteristics ▪ Electrochemical Sensors and Biosensors ▪ Optical Sensors ▪ Acoustic Sensors **Ultrasonic sensors for imaging** ▪ Principles of generation and detection of ultrasound ▪ Fundamentals of acoustic wave propagation ▪ Methods of signal optimization and signal extraction ▪ New trends in ultrasonic sensor development and imaging principles
Literature	[1] Peter Gründler, Chemical Sensors An Introduction for Scientists and Engineers, Springer Link [2] Ghenadii Korotcenkov: Chemical Sensors, Vol 1: General Approaches (Sensor Technology), Momentum press 2010 [3] J. Fraden, Chemical and Biological sensors, Chapter 18 from Handbook of Modern Sensors (pp 645-697) [4] Florinel-Gabriel Banica: Chemical Sensors and Biosensors: Fundamentals and Applications, Wiley & Sons, by John Wiley & Sons, Ltd [5] Watson, J., Chemical Sensors 1-6, Momentum Press 2010. [6] Sanches, J.M., Ultrasound Imaging: Advances and Applications, Springer 2012, dx.doi.org/10.1007/978-1-4614-1180-2. [7] Scabo, T.L., Diagnostic Ultrasound Imaging, Elsevier, 2007.
Language	English
Teaching	Lecture
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90 min

(continued on the next page)

(continued)

Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS lecture chemical and biological sensors , 2 SWS lecture ultrasonic sensors for imaging 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
Language	English
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 120 min
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: 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)

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	
Language	English
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 90 min
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
	▪ Simple flows
	  ▫ Hydrostatics
	  ▫ Couette and 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	
Language	English
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	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 summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Claus-Dieter Ohl (FNW-IEP)

Micro Optics

Objectives and content	**Objectives:**
	After completing this course, the students will have acquired on the one hand a background in optics that is relevant to apply and derive the working principles of micro-optical devices and understand their limitations. On the other hand, they will have a broad overview over the working principles of the most common micro-optical devices.
	Content:
	▪ Review of optics
	  ▫ Geometric optics
	  ▫ Wave optics (Diffraction and interference, Fourier optics, Propagation in a wave guide)
	▪ Micro-Optomechatronic devices for imaging and beam shaping
	  ▫ Adaptive lenses
	  ▫ Adaptive mirrors and spatial light modulators
	  ▫ Scanning mirrors
	  ▫ Micro lenses, Shack-Hartmann sensor
	▪ Micro-optical devices for fiber optics
	  ▫ Fiber optic switches
	  ▫ Ring resonators, whispering gallery resonators
	  ▫ Elements of integrated fiber optics
	▪ Meta optics
	  ▫ Optical metamaterials, photonic crystals
	  ▫ Diffractive optics, metalenses

Literature	
Language	English
Teaching	Lecture, Tutorial
Prerequisites	Engineering mathematics and physics, e.g., bachelor degree in Electrical Engineering, Mechanical Engineering, Physics or related discipline. Basic knowledge of micro mechanics and micro actuators is recommended.
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: Post processing of lectures, solving and preparation of exercises, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Matthias Wapler (FEIT-IMT)

Microscopic Methods

Objectives and content	**Objectives:** Microscopic methods are fundamental for characterizing the structure, surface and the chemical composition of materials, cells and tissues in order to understand their behaviours and interactions. Various physical effects can be used both for imaging of surfaces and for analyzing the structure and/or chemical composition. Depending on the microscopic method used and the preparation needed, these are destructive or non-destructive methods. The choice of methods is essentially determined by the combination of the aim of the investigation and the nature of the material, cell or tissue. This lecture will focus on the combination of preparation and the type of microscopic investigation with method-related applications as well as individual limitations such as detection limits, lateral and spectral resolutions, qualitative and/or quantitative measurements and others aspects for different types of microscopy. **Content:** ▪ preparation of materials and tissues for microscopy ▪ fundamentals and applications of optical microscopy ▪ fundamentals and applications of electron microscopy ▪ materials characterization and analysis ▪ fluorescence microscopy
Literature	
Language	English
Teaching	Lecture, Lab course
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 (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Lab course Autonomous work: self-study
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr.-Ing. Markus Wilke (FMB-IWF)

Microsystems Processes and Technologies

Objectives and content	**Objectives:** After completing this module, the students are aware of the general fabrication processes of micro systems. They will know the general strategy of how to build a micro system with additive and subtractive processes, the implications on micro systems design and the individual processes and their limitations. They will also have a general understanding of the relevant materials and the characterization techniques. While we will focus on the fabrication of micro electro mechanical systems such as sensors and micro actuators, the concepts are transferable to micro electronics, and we will also briefly cover the relevant nanometer-scale lithography. We will cover both the classical cleanroom-based processes and modern rapid prototyping processes, and in addition, we will cover the most relevant traditional inorganic and modern organic materials and the structural, chemical and dynamic MEMS characterization techniques. **Content:** ▪ Introduction ▫ Why not classical fabrication? Parallel vs. serial processes. Planar systems ▫ Basic MEMS materials, silicon ▫ Clean rooms, yield, wafers ▪ Classical micro processes ▫ Lithography: Optical, EUV, multi-patterning, e-beam, x-ray ▫ Subtractive processes: Chemical, physical, (an)isotrophy, selectivity ▫ Additive processes: Surface modification, thin film, thick film, physical, chemical, epitaxy ▫ Back end processes: Bonding, contacting, encapsulation, dicing ▫ Special processes: DRIE, LIGA ▪ Modern/rapid prototyping processes ▫ Laser ablation ▫ 2-photon lithography ▫ Surface nano structures ▫ Alternative/organic MEMS materials ▪ Characterization techniques ▫ (Electron) microscopy ▫ X-ray Spectrometry, diffractometry ▫ Force microscopy, surface profilometry ▫ Interferometry, vibrometry
Literature	
Language	English
Teaching	Lecture
Prerequisites	Engineering mathematics and physics, e.g., bachelor degree in Electrical Engineering, Mechanical Engineering, Physics or related discipline.
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)

(continued on the next page)

(continued)

Work load	Time of attendance: 3 SWS Lecture Autonomous work: Post processing of lectures, solving and preparation of exercises, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Matthias Wapler (FEIT-IMT)

Mini Research Project

Objectives and content	**Objectives:** With this module students with interest in research will be prepared for their thesis and future research work. After completing the module, students are able to solve complex scientific and engineering research tasks in the field of medical technology independently, proactively as well as creatively and are able to document and present their results on a scientifically high level. **Content:** The students work on current research projects in the field of their interest. The project topic should be related to medical technology. One research assistant of the respective project supervises the student. The project has to be chosen by the student. The following topics are possible: ▪ Design and development of medical hardware (e.g. electronic circuits) ▪ Design and development of dedicated algorithms/ software for medical technology ▪ Design and development of simulators or prototypes (software or hardware) ▪ Development of specific solutions in the field of imaging and image processing (e.g. x-ray, CT, MRI, PET, US) The exact task will be defined in consultation with the respective supervisor according to the interests of the student.
Literature	Depending on the research project
Language	English
Teaching	None
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Poster presentation
Credit Points	5 CP = 150 h (0 h time of attendance + 150 h autonomous work)
Work load	Time of attendance: - Autonomous work: depending on the project (150 h)
Frequency	Every winter semester
Duration	One semester
Responsible person	Supervisor of the Mini Research Project

MRI Pulse Sequence Design

Objectives and content	**Objectives:** The attendees get a deeper insight into signal processing of magnetic resonance imaging (MRI). They will gain knowledge of the fundamental acquisition process, image reconstruction and pulse sequence design of clinical contrasts. One main subject will be the new sequence design language MR and its application development environment (ADE) SketchMR. **Content:** ▪ Basic MR physics (excitation, signal, Bloch equations, T1, T2) ▪ MR instrumentation (magnet; transmission: RF system, gradient system; receiving: receiving coil, gradient system - readout gradient, ADC; digital MR signal processing) ▪ MR image encoding/reconstruction ▪ MR pulse sequences (MR#, SketchMR) ▪ MR simulation ▪ Inverse problems in MR image reconstruction
Literature	[1] Spin Dynamics: Basics of Nuclear Magnetic Resonance. 2nd Edition. Wiley, 2008 [2] Understanding NMR Spectroscopy. 2nd Edition. Wiley, 2010 [3] Handbook of MRI Pulse Sequences. Academic Press, 2004
Language	English
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar Work
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: Follow-up and preparation of the seminar, preparation of the seminar work
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. rer. nat. Stefan Röll (Neoscan Solutions GmbH)

MR System Engineering

Objectives and content	**Objectives:** This course provides an overview and detailed knowledge of the hardware and software architecture of a medical MRI scanner in lectures and in practical sessions. The OCRA Tabletop MRI scanner and the Flextronic electronics prototyping laboratory provide the possibility to gain hands on experience with a state-of-the-art MRI systems, and rapid prototyping development. In this course, participants will team up in small groups. Each group will work on a specific hardware or software project throughout the semester. This includes project preparation and planning, hands-on hardware or software development as well as MR measurements throughout the semester. Hardware projects may include CAD modelling, design of electronics and printed circuit boards or the programming of microcontrollers. Software projects are related to low level system communication, scripting and programming of measurements, graphical user interphase design or MRI sequence programming. Measurement projects may include the design of measurement protocols and data generation and processing. The hardware or software prototype or the measurement results together with a project presentation are the deliverables upon completion. **Content:** ▪ MRI basics ▪ MRI scanner system architecture ▪ MRI software architecture, sequence and measurement protocols ▪ MRI system hardware components ▪ Group projects The maximum number of participating students is restricted to 16.
Literature	Magnetic Resonance Imaging - Physical Principles and Sequence Design, Robert W. Brown, ISBN-10: 3800733056
Language	English
Teaching	Lecture, Tutorial
Prerequisites	▪ Successful completion of the module: Methods of MRI ▪ Selection of limited seats based on a preliminary written entrance exam
Recommended prerequisites	Bachelor in Medical Systems Engineering, physics or related studies, good knowledge in electronics, informatics or mechanics; prior attendance of the lecture Basics of MR is recommended
Applicability of the module	Master program
Prerequisite for the admission to any examination	Laboratory certificate
Examination	Project presentation
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: : Project processing and preperation for the presentation
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. habil. Oliver Speck (FNW-IEP), Marcus Prier (FNW-IEP)

Nuclear Medicine

Objectives and content	**Objectives:** The students will learn about the fundamentals of physics, technology and radionuclides used in nuclear medicine. The course will cover the basics of radioactive processes and production methods of radiopharmaceuticals. It will then describe the various applications for diagnostic and therapeutic applications, its measurements, specific radiation protection measures, quality control and current developments including theranostics. **Content:** ▪ The basic elements of matter ▪ Decay processes ▪ Radiation therapy with radioisotopes ▪ Decay processes ▪ Radiation therapy with radioisotopes ▪ Brief overview on medical imaging with radioisotopes ▪ Tracers principle and development, medical relevant nuclides ▪ Production and quality control of radiopharmaceuticals ▪ Specific tasks for radiation protection ▪ Theranostic principle and personalized therapy ▪ Legal aspects (radiation protection vs. pharmaceutical production)
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 [4] Handbook of Nuclear Chemistry, Eds. Vertes, Nagy, Klencsar, Lovas, Rösch [5] Nuklearmedizin - Qualitätssicherung im Nuklearmedizinischen Labor, Ed. Gildehaus
Language	English
Teaching	Lecture, Exercise, Lab Course
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90 min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Exercise, 2 SWS Laboratory course (block course in semester break) Autonomous work: Rework of lectures and exercises, preparation of exercises, preparation and review of the laboratory course
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. C. Hoeschen (FEIT-IMT), Dr. E. Eppard (FME), Dr. A. Hohn (FME)

Orthopedic and sport medicine diagnostic, operative and treatment applications

Objectives and content	**Objectives:** ▪ Detailed knowledge of diagnostic methods und importance for diagnosis ▪ Detailed knowledge of treatment applications and apparative necessities in operative orthopedic treatments methods ▪ Knowledge concerning body structure and function of joints and spine ▪ Knowledge of treatment and training modalities for a human body ▪ Understanding of overall functional necessities of operative and conservative treatment methods **Content:** ▪ Diagnostics modalities (X-Ray, EOS, CT, MRI) and value for the diagnosis ▪ Spine: anatomical and functional fundamentals, diagnostic and treatment modalities, global function ▪ Joints and muscles fundamentals: functional test, training methods and apparatus ▪ Robotics and Virtual Reality: applications in surgery and perioperative use ▪ Peripheral joints: basic anatomy and function ▪ Artificial joints: principal function and materials, basic principles of total joint replacement, materials ▪ Sports traumatology: basic anatomy and function of ligaments and cartilage, repair and replacement using autologous and artificial materials ▪ Orthotics: functional braces, unloading of joints, materials
Literature	
Language	English
Teaching	Lecture, Seminar, Visitation in the operating room
Prerequisites	None
Recommended prerequisites	Basic knowledge of diagnostic and treatment tools in medicine
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 45 min
Credit Points	5 CP = 150 h (20 hours lecture attendance, 16 hours visitation operating room, 114 hours of rework and exam preparation)
Work load	Time of attendance: 2 SWS Lecture Autonomous work: self-study
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. med. Jörg Franke, Prof. Dr. Christian Stärke, Simon Overkamp (Zentrum für Unfallchirurgie und Orthopädie, Klinikum Magdeburg)

Pharmacokinetic and Pharmacodynamic Modeling

Objectives and content	**Objectives:** The students will learn how to derive pharmacokinetic compartment models including various drugs and administration routes on different complexity scales. Additionally, fundamental knowledge of mass balances, transport phenomena and numerical simulation methods will be illustrated. The derived models will be implemented in MATLAB and the model predictions analyzed and discussed. **Content:** ▪ Introduction into pharmacokinetic and pharmacodynamic modeling ▪ Pharmacokinetic and pharmacodynamic parameters ▪ Fundamentals for modeling biological and medical systems ▪ Constitutive equations and transport phenomena ▪ Numerical methods for solving differential equations ▪ Methods for optimal experimental design
Literature	P. Macheras, A. Iliadis "Modeling in Biopharmaceutics, Pharmacokinetics and Pharmacodynamics: Homogeneous and Heterogeneous Approaches"
Language	English
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	Basic knowledge in MATLAB programming and biological statistics
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 Seminar Autonomous work: Preparation of the lectures and seminars
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT), Dr.-Ing. Melanie Fachet (FEIT-IMT)

Planar Medical Imaging Techniques

Objectives and content	**Objectives:** The course gives an introduction to planar medical imaging technologies. Beside projectional radiography other relevant planar imaging techniques are presented. For every imaging technique we will go quickly into the image acquisition and processing and look at the key technologies that are needed to realize the individual imaging setups. **Content:** 1. X-ray projection radiography a) Absorption b) Dark field c) Phase contrast 2. Optical imaging a) Microscopy b) Infrared c) Coherence 3. Ultrasound and impedance imaging 4. Examples for molecular imaging a) Magnetic nanoparticle imaging b) Scintigraphy
Literature	[1] Diakides, Medical Infrared Imaging - Principles and Practices (2012) [2] Plonsey, Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields (1995) [3] Paganin, Coherent X-ray Optics (2006) [4] Scherer, Grating based X-ray phase contrast mammography (2016) [5] Bushberg, The Essential Physics of Medical Imaging (2011) [6] Oppelt, Imaging systems for medical diagnostics (2005)
Language	English
Teaching	Lecture, Exercise, Short Talk
Prerequisites	Basics of Medical Image Science
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Short talk
Examination	Written examination 90 min
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 Exercise + Short Talk Autonomous work: Preparation of the lectures, exercises and short talk
Frequency	Every winter 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.
Language	English
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: Solving homework assignments, Preparing for lectures, preparing for exam
Frequency	Every summer semester
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Nicola D'Ascenzo (FEIT)

Principles in clinical trials, market introduction and market surveillance of medical devices

Objectives and content	**Objectives:** In contrast to pharmaceuticals, no worldwide uniform legally requirements are available for the approval and CE certification of medical devices. Every manufacturer is responsible to set up the process and documentation of his medical devices to get it approved according to defines OECD Guidelines and ISO norms. The regulatory affair offers an unexpectedly exciting and diverse range of tasks for all students, especially in small and medium-sized companies. As part of the compulsory elective module, we want to deepen topics from the field of clinical studies as well as market introduction and market surveillance in this module. **Content:** The content is based on the specifications for the European CE approval and relevant DIN ISO specification. It includes following basics of the pre-market phase: Risk management and assessment, risk-benefit analysis, regulatory affairs manager, technical documentation, quality management, PDCA cycle, patient safety vs. Customer satisfaction, clinical evaluation and proof of effectiveness. After the lectures, different international admission procedures in the USA, Russia, Brazil, Japan, ASEAN, Canada, China, India, Saudi Arabia and Mexico will be examined. Therefor we will build groups of two students to perform a Term work. Content of work are selected examples to illuminate the approval procedures for different medical device classes and to address particular regulatory issues. These Term work are presented and discussed in a short lecture to all students. The homework is 50% of the examination performance. In addition, an exam is written at the end of the course, which also accounts for 50% of the total grade.
Literature	
Language	English
Teaching	Lecture, Seminar
Prerequisites	Attending the module: Introduction to the approval process of medical devices, is a prerequisite.
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Term paper and its presentation
Examination	Written examination 90 min (Term paper and exam each 50% of the final grade)
Credit Points	5 CP = 150 h (45 h time of attendance + 105 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Seminar Autonomous work: follow-up lecture and exercises - elaboration of term paper
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. Melanie Fachet (FEIT-IMT), Sinja Lagotzki (InLine-Med GmBH), Daniel Gwinner (Neoscan Solutions GmbH)

Research Project

Objectives and content	**Objectives:** With this module, particularly high-performing students with interest in research will be optimally prepared for their thesis and future research work. After completing the module, students are able to solve complex scientific and engineering research tasks in the field of medical technology independently, proactively as well as creatively and are able to document and present their results on a scientifically high level. **Content:** The students work on current research projects in the field of medical technology. The project topics are scientific-practical and real contemporary issues. At least one research assistant of the respective project supervises the student. Depending on the students' interest, the following topics are possible: ▪ Design and development of medical hardware (e.g. electronic circuits) ▪ Design and development of dedicated algorithms/ software for medical technology ▪ Design and development of simulators or prototypes (software or hardware) ▪ Development of specific solutions in the field of imaging and image processing (e.g. x-ray, CT, MRI, PET, US) The exact task will be defined in consultation with the respective supervisor according to the interests of the student.
Literature	Depending on the research project
Language	English
Teaching	None
Prerequisites	Completion of all compulsory modules of the first semester; proactive personality; excellent academic performance during Bachelor and current Master; detailed application for the research project, acceptance by the examination board
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Presentation & written work
Credit Points	15 CP = 450 h (0 h time of attendance + 450 h autonomous work)
Work load	Time of attendance: - Autonomous work: depending on the project (450 h)
Frequency	Every winter semester (also during summer if time of matriculation was winter semester), maximum of 7 students per admission year
Duration	Two semesters
Responsible person	Supervisor of the Research Project

Rheology and Rheometry

Objectives and content	**Objectives:** The students have acquired all competences to describe and model the behavior of complex fluids after completion of this module. They understand all key concepts and know where complex fluids are important for practical purposes. They are enabled to recognize, characterize, describe and deal with complex fluids. Thanks to accompanying exercises with hands-on in the lab, the students are additionally able to conceive and carry out the measurements necessary to characterize the viscous and/or elastic behavior of fluids and to interpret the obtained results. **Content:** Many fluids come with non-Newtonian properties. Those influence viscous losses, transport properties, product quality, and material properties. Considering the high viscosity of most products, the lecture concentrates mostly on laminar flow conditions and is structured as follows: ▪ Basics of Rheology and Rheometry, introducing viscosity ▪ Movement of a fluid, Couette flow and its solutione ▪ Newtonian fluids ▪ Shear-thinning and shear-thickening fluids, power law ▪ Yield stress, Bingham fluids ▪ Thixotropy and rheopexy ▪ Analytical flow solutions in a pipe ▪ Capillary viscometers ▪ Rotational rheometers ▪ Visco-elastic fluids, Maxwell model, complex fluid properties ▪ Oscillation rheometers ▪ Reiner-Rivlin fluids, generalized Newtonian fluids ▪ Elongational viscosity, relation of Trouton ▪ Rheological description of blood
Literature	Own lecture notes, further book recommendations provided during 1st lecture
Language	English
Teaching	Lecture, Exercises with Hands-on in the Lab:
Prerequisites	Basics of fluid mechanics, sufficient mathematical competences (limited seats for FEIT students)
Recommended prerequisites	
Applicability of the module	Master programm
Prerequisite for the admission to any examination	success for all hands-on entry exams as well as hands-on protocols
Examination	Oral examination, including overall grade from hands-on labs
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	2 SWS Lecture, 1 SWS Exercises with hands-on in the Lab
Frequency	Every winter semester
Duration	One Semester
Responsible person	Prof. Dr.-Ing. habil. Dominique Thevenin (FVST - LSS)

Scientific Working

Objectives and content	**Objectives:** The skills that are essential when working as part of scientific team are collaboration with other team members, presenting results of the work and evaluation of the work of others. This course aims to strengthen these skills in the students and prepare them for active collaboration on further scientific projects. **Content:** ▪ Prepare 20 min presentation based on the per-reviewed scientific paper from reputable journal. ▪ Prepare video with his/her delivery of the presentation. ▪ Review presentations of 2 other people. ▪ Respond to the reviewers regarding his/her own presentation. ▪ Deliver the presentation/prepare final video. ▪ Evaluate final presentation of two other students.
Literature	
Language	English
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation and evaluation of the class activities
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 (winter semester on demand)
Duration	One semester
Responsible person	Dr.-Ing. Melanie Fachet (FEIT-IMT)

Soft Matter and Microfluidics Lab

Objectives and content	**Objectives:** The participant will: ▪ be trained in the design, planning and conduction of experiments concerning soft matter and fluids ▪ autonomously design and produce parts of the experimental setup ▪ work out theoretical background and relationships of the experiment ▪ prepare a scientific lab report and give an oral presentation summarizing theory, experimental strategy, and critically discussing the results **Content:** Experiments on the following topics: ▪ design and production of microfluidic systems with lithographic and maskless methods (3D FDM printing, laser cutting, stereo lithography) ▪ micro-particle tracking and velocimetry for flow analysis ▪ measurement of diffusion coefficient with optical methods Design and conduction of one experiment chosen among: ▪ electro-osmosis ▪ non-linear acoustics, acoustic streaming and acoustophoresis ▪ t-channel droplet generator ▪ non-linear bubble oscillator and sonoluminescence ▪ aerosol generation and acoustic levitation ▪ ferrofluidics
Literature	
Language	English
Teaching	Lab Course, Seminar, Lecture
Prerequisites	None
Recommended prerequisites	Participation lecture Microfluidics (Prof. Claus-Dieter Ohl), held in the same semester
Applicability of the module	Master program
Prerequisite for the admission to any examination	Active participation in the course
Examination	Preparation of a lab protocol, and an oral presentation defending the experimental data
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS
Frequency	Every two or three summer semester
Duration	One semester
Responsible person	Dr. rer. nat. Fabian Reuter (FNW - IfP)

Solution Design in Medical Engineering

Objectives and content	**Objectives:** The students will: ▪ learn to propose and design a medical engineering related project. ▪ learn about design methodology and previous successful student projects. ▪ be introduced to using 3D design software to draw items which are needed for their projects. ▪ get to use the Arduino platform to work on small projects in the class. ▪ be introduced to making Android phone App. ▪ present their project to the class and demonstrate its functionalities. ▪ make a website or blog about their project. **Content:** Students will propose, work and present a medical engineering related design project in a small group. The projects are thematic for each semester. With the support from the lecturer, the students will learn how to manage their project and their fellow teammates. They will do prototyping and debugging in a team. They will document their journey and learning experience in a website or blog. The final presentation includes live demonstration of their project.
Literature	
Language	English
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 semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

Statistical Methods I

Objectives and content	**Objectives:** The students: ▪ acquire basic knowledge of descriptive statistics for univariate data and for analysing simple relationships, ▪ develop the ability to analyse data using appropriate tools, ▪ are able to compute probabilities for some standard distributions, ▪ understand how real world problems can be modelled by using probabilistic concepts. **Content:** ▪ Variables and measurement levels ▪ Methods of descriptive statistics and explorative data analysis: tabular and graphical methods for summarizing data and empirical measures of location and variability (e.g. frequency tables, boxplot, mean, median, quantiles, variance and standard deviation) ▪ Elementary probability concepts, discrete and continuous random variables, probability distributions, probability density function and cumulative distribution function ▪ Theoretical measures of location and variability (expected value, variance, standard deviation, quantiles) ▪ Statistical independence, conditional probability, Bayes theorem ▪ Special distributions: Bernoulli, Binomial, Poisson, continuous uniform, exponential and normal distributions ▪ Law of large numbers, central limit theorem ▪ Simple concepts for relationships: contingency tables and Pearson correlation
Literature	Newbold, P.; Carlson, W.; Thorne, B. (2013): Statistics for Business and Economics. 8 th edition, Pearson: Harlow.
Language	English
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 60 min
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: re-working of lectures, autonomous execution of exercises, preparation of the exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Claudia Kirch (FMA-IMST), Prof. Dr. Anja Janssen (FMA-IMST)

Statistical Methods II

Objectives and content	**Objectives:** The students: ▪ are introduced to basic concepts of inferential statistics, ▪ acquire the ability to select and apply appropriate methods for classical estimation and testing problems, ▪ acquire the ability to translate real-world economic problems into statistical terms, ▪ are able to relate statistical results back to real-world applications. **Content:** ▪ Point and interval estimation ▪ Testing statistical hypotheses ▪ Properties of point estimators ▪ Sampling distributions ▪ Classical estimation and testing procedures for one-sample and two-sample problems ▪ Goodness of fit tests and tests of independence ▪ Checking distributional assumptions.
Literature	Newbold, P.; Carlson, W.; Thorne, B. (2013): Statistics for Business and Economics. 8 th edition, Pearson: Harlow.
Language	English
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	Introduction to Probability and Statistics
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 60 min
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: re-working of lectures, autonomous execution of exercises, preparation of the exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Claudia Kirch (FMA-IMST)

Theoretical Neuroscience I

Objectives and content	**Objectives:** Introduces theoretical principles of brain function to participants without strong math and physics background. Helps participants to develop independent judgment about current theoretical ideas and concepts pertaining to brain function. Gets participants to apply these concepts in computational exercises. Course objectives are ambitious, but realistic and helpful for a career in neuroscience or related fields. Participants do not become theoreticians, but competent to interact productively with theoreticians. **Content:** **Neuroelectronics (Chapters 5 and 6 of D&A):** 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, synaptic potentials and short-term plasticity. **Encoding and decoding (Chapters 1 to 4 of D&A):** Tuning curves and receptive fields, linear systems theory and linear filter models, reverse correlation methods, signal-detection theory and psychometric function, neurometric function, choice task performance, population coding, maximum likelihood decoding, Fisher information, Shannon information and application to neural activity.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Sterrat, Graham, et al., "Principles of Computational Modeling in Neuroscience", 2011
Language	English
Teaching	Lecture, Tutorial
Prerequisites	Basic programming skills (Matlab)
Recommended prerequisites	Undergraduate courses in physics, mathematics or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120 min
Credit Points	5 CP = 150 h (70 h time of attendance + 80 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture, 2 SWS Tutorial Autonomous work: programming exercises, exam preparation
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Jochen Braun Ph.D. (FNW-IBIO)

Theoretical Neuroscience II

Objectives and content	**Objectives:** Introduces theoretical principles of brain function to participants without strong math and physics background. Helps participants to develop independent judgment about current theoretical ideas and concepts pertaining to brain function. Gets participants to apply these concepts in computational exercises. Course objectives are ambitious, but realistic and helpful for a career in neuroscience or related fields. Participants do not become theoreticians, but competent to interact productively with theoreticians. **Content:** **Network models (Chapter 7 of D&A):** Rate models of network dynamics, linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states. **Neural plasticity (Chapter 8 of D&A):** Types of plasticity, activity-dependent plasticity, associative learning, models of neural development. **Reinforcement learning (Chapter 9 of D&A):** Conditioning, Rescorla-Wagner rule, temporal-difference learning, policy learning, actor-critic models. **Representational learning (Chapter 10 of D&A):** Generative models, K-means, expectation maximization, principal component analysis, sparse representations, independent component analysis.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Wilson, "Spikes, Decisions and Actions: the Dynamical Foundations of Neuroscience", OUP 1999 [3] Sutton & Barto, "Reinforcement Learning: an Introduction", MIT 1999
Language	English
Teaching	Lecture, Tutorial
Prerequisites	Basic programming skills (Matlab)
Recommended prerequisites	Undergraduate courses in physics, mathematics or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120 min
Credit Points	5 CP = 150 h (70 h time of attendance + 80 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture, 2 SWS Tutorial Autonomous work: programming exercises, exam preparation
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Jochen Braun Ph.D. (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 Interfaces: 3D-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
Language	English
Teaching	Lecture, Seminar
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 120 min
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
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG), Prof. Dr. Christian Hansen (FIN-ISG)

Tissue Engineering Lab

Objectives and content	**Objectives:** Tissue engineering is an interdisciplinary field that is very application-oriented. In the lecture: Introduction in Tissue Engineering, you have worked out the theoretical basics and heard about numerous, very different fields of application. In this practical course, we want to learn preparing hydrogels and applying tissue models for the risk assessment as well as the necessary molecular evaluation. This course helps you to decide whether tissue engineering is a field for your master's thesis. **Content:** We start with the production and material characterization of hydrogels. Then we will manufacture certified tissue models for testing chemicals. Finally, we carry out a risk assessment on this tissue model. We will evaluate this assessment with molecular methods.
Literature	
Language	English
Teaching	Lab Course and Tutorial (Practical course and tutorial in small groups to discuss results and protocol preparation for final protocol of the risk assessment)
Prerequisites	None
Recommended prerequisites	Attending Introduction in Tissue Engineering
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Protocols and final report of the risk assessment
Credit Points	5 CP = 150 h (100 h time of attendance + 50 h autonomous work)
Work load	Time of attendance: 80 hours of present time in the lab (10 full days), 20 hours exercise for critical review of the experimental data and reports Autonomous work: 50 hours of independent work (follow-up experiments and exercises/discussion of the results - elaboration of final report)
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. biol. hum. Heike Walles (FVST - ICH)

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
Language	English
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
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG)