



OTTO VON GUERICKE  
UNIVERSITÄT  
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EIT

FAKULTÄT FÜR  
ELEKTROTECHNIK UND  
INFORMATIONSTECHNIK

## Module descriptions

Master  
Medical Systems Engineering

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# Contents

<b>Advanced Security Issues in Medical Systems</b> . . . . .	<b>4</b>
<b>Advances in Radiation and Medical Physics</b> . . . . .	<b>5</b>
<b>Anatomy for Engineering Students</b> . . . . .	<b>6</b>
<b>Basics of Radiation Physics and Image Science</b> . . . . .	<b>7</b>
<b>Computational Biomechanics</b> . . . . .	<b>8</b>
<b>Computational Fluid Dynamics</b> . . . . .	<b>9</b>
<b>Computed Tomography</b> . . . . .	<b>10</b>
Submodule: Methods on CT . . . . .	10
Submodule: Advances in CT . . . . .	11
Sub-Module: Lab course CT . . . . .	11
<b>Computer Assisted Surgery</b> . . . . .	<b>13</b>
<b>Digital Information Processing</b> . . . . .	<b>14</b>
<b>Digital Information Processing Lab</b> . . . . .	<b>15</b>
<b>Electromagnetic Compatibility (EMC)</b> . . . . .	<b>16</b>
<b>Entwicklung von Medizinprodukten</b> . . . . .	<b>17</b>
<b>Experimental Neuroscience - from study design in motor research to brain-computer-interfaces</b> . . . . .	<b>18</b>
<b>Finite Element Method</b> . . . . .	<b>19</b>
<b>Human-Computer Interfaces in Medicine</b> . . . . .	<b>20</b>
<b>Hybrid Imaging</b> . . . . .	<b>21</b>
<b>Image Coding</b> . . . . .	<b>22</b>
<b>Introduction in Tissue Engineering</b> . . . . .	<b>23</b>
<b>Introduction to Deep Learning</b> . . . . .	<b>24</b>
<b>Introduction to Probability and Statistics</b> . . . . .	<b>25</b>
<b>Introduction to Programming Techniques in Engineering</b> . . . . .	<b>26</b>
<b>Introduction to the approval process of medical devices</b> . . . . .	<b>27</b>
<b>Introduction to the pre- market phase in the approval process of medical devices</b> . . . . .	<b>28</b>
<b>Machine Learning for Medical Systems</b> . . . . .	<b>29</b>
<b>Master Thesis</b> . . . . .	<b>30</b>
<b>Mathematical Foundations</b> . . . . .	<b>31</b>
<b>Mathematical Modeling of Physiological Systems</b> . . . . .	<b>32</b>
<b>Medical Measurement Technology</b> . . . . .	<b>33</b>
<b>Medical Visualization</b> . . . . .	<b>35</b>
<b>Methods of MRI</b> . . . . .	<b>36</b>

<b>Microfluidics: Theory and Applications</b> . . . . .	<b>37</b>
<b>MRI Pulse Sequence Design</b> . . . . .	<b>38</b>
<b>MR System Engineering</b> . . . . .	<b>39</b>
<b>Nuclear Medicine</b> . . . . .	<b>40</b>
<b>Pharmacokinetic and Pharmacodynamic Modeling</b> . . . . .	<b>41</b>
<b>Planar Medical Imaging Techniques</b> . . . . .	<b>42</b>
<b>Positron Emission Tomography (PET)</b> . . . . .	<b>43</b>
<b>Principles in clinical trials, market introduction and market surveillance of medical devices</b> . . . . .	<b>44</b>
<b>Research Project</b> . . . . .	<b>45</b>
<b>Rheologie und Rheometrie</b> . . . . .	<b>46</b>
<b>Scientific Working</b> . . . . .	<b>47</b>
<b>Soft Matter and Microfluidics Lab</b> . . . . .	<b>48</b>
<b>Solution Design in Medical Engineering</b> . . . . .	<b>49</b>
<b>Theoretical Neuroscience I</b> . . . . .	<b>50</b>
<b>Theoretical Neuroscience II</b> . . . . .	<b>51</b>
<b>Three Dimensional and Advanced Interaction</b> . . . . .	<b>52</b>
<b>Tissue Engineering Lab</b> . . . . .	<b>53</b>
<b>Visual Analytics in Healthcare</b> . . . . .	<b>54</b>

# Advanced Security Issues in Medical Systems

Objectives and content	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"> <li>▪ work on selected current topics on technical, organizational, judicial, social and ethical topics in IT security on the example of security considerations in medical sciences</li> <li>▪ be enabled to understand and devise application field specific IT security strategies</li> </ul> <p><b>Content:</b></p> <p>Selected current topics on technical, organizational, judicial, social and ethical topics, e.g.:</p> <ul style="list-style-type: none"> <li>▪ Medical information systems</li> <li>▪ Secure data storage and processing for person related and medical data</li> <li>▪ Security in medical IT infrastructures: system-, network-, and application</li> <li>▪ Special considerations for digital signal (image and audio) processing for medical records</li> <li>▪ Security management in medical information systems</li> <li>▪ Standardization, certification and evaluation of IT security for medical application scenarios and systems</li> <li>▪ Case studies on IT security mechanisms and problems in medicine</li> </ul> <p>Seminar:</p> <ul style="list-style-type: none"> <li>▪</li> <li>▪ Presence at three scheduled times</li> <li>▪ Topic presentation distribution and registration</li> <li>▪ Milestone presentation with structure and first, preliminary results</li> <li>▪ Final presentation containing all results</li> </ul>
Literature	For literature see <a href="http://omen.cs.uni-magdeburg.de/itiamsl/lehre/">http://omen.cs.uni-magdeburg.de/itiamsl/lehre/</a>
Teaching	Seminar
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: 3 SWS Seminar Autonomous work: Literature research, Scientific work on the topic, Slides and report preparation
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Jana Dittmann (FIN-ITI)

# Advances in Radiation and Medical Physics

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ol style="list-style-type: none"> <li>1. Refreshing Medical Physics and radiation protection</li> <li>2. Dosimetry</li> <li>3. Numerical dosimetry - Biokinetics</li> <li>4. Numerical dosimetry - MonteCarlo Simulations</li> <li>5. Radiation Therapy Monitoring</li> <li>6. HIFU therapy</li> <li>7. Breath gas analysis</li> <li>8. Audiology Summary / new directions in medical physics e.g. AI applications</li> </ol>
Literature	<p>[1] The 2007 recommendations of the ICRP, ICRP 103 (2007)</p> <p>[2] Caner, Radiation Protection in Medical Physics (2010)</p> <p>[3] ICRP computational framework for internal dose assessment (2015)</p> <p>[4] Vassiliev, Monte Carlo Methods for Radiation Transport (2017)</p> <p>[5] Wong, Advanced and Emerging Technologies in Oncology (2018)</p> <p>[6] Podgorsak, Radiation Physics for Medical Physicists (2016)</p>
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	<p>Time of attendance in winter semester: 2 SWS Lecture, 1 SWS Tutorial</p> <p>Time of attendance in summer semester: 2 SWS Lab Project</p> <p>Autonomous work: Preparation of the lectures, tutorials and lab project, preparation of the exam</p>
Frequency	Every winter semester
Duration	Two semesters
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

# Anatomy for Engineering Students

Objectives and content	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ Students acquire basic knowledge of anatomy and physiology of the central and peripheral nervous system</li> <li>▪ Students acquire basic knowledge of anatomy and physiology of the locomotion system</li> <li>▪ Students acquire basic knowledge of anatomy and physiology of the cardiovascular system</li> <li>▪ Students acquire basic understanding of the human metabolic organs</li> <li>▪ Students apply knowledge on biomechanical properties of the structures/organs discussed in a problem-based approach</li> <li>▪ Students apply knowledge on consequences and requirements for medical devices and implants in a problem-based approach</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Microscopic and macroscopic structures and functions of human nervous system, musculoskeletal system, cardiovascular system, and metabolic systems (digestive tract, excretory tracts, hormonal regulation)</li> <li>▪ Literature search on biomechanical properties and functionality of the discussed structures, and application in biomedical engineering</li> <li>▪ 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</li> </ul>
Literature	Anatomy and Physiology books and atlases, original research articles, reviews, PubMed, open E-learning sources
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 <i>STIMULATE</i> , Magdeburger Arbeitsgemeinschaft für Forschung unter Weltraum- und Schwerelosigkeitsbedingungen MARS, University of Magdeburg, Institute of Anatomy, University of Bern)

# Basics of Radiation Physics and Image Science

Objectives and content	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"> <li>▪ get an overview about radiation principles including types of ionizing radiation and their behaviour</li> <li>▪ learn about the biological effects of ionizing radiation</li> <li>▪ become acquainted with dosimetry</li> <li>▪ get to know to system theory for medical imaging systems</li> <li>▪ learn to understand the differences between Fourier based and task based image quality descriptions</li> <li>▪ understand how image quality can be described by different types of observers (human and model observers)</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Radiation Physics for alpha-, beta-, gamma-, neutron- and X-ray radiation</li> <li>▪ Dosimetry</li> <li>▪ MTF, NPS and DQE</li> <li>▪ Ideal observer, human observer models, ROC curves</li> </ul>
Literature	provided by e-learning system
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
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

# Computational Biomechanics

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Overview about modern computational methods in mechanics and there application in biomechanics and medical engineering</li> <li>▪ Introduction in mathematical modeling</li> <li>▪ Discretization methods:             <ul style="list-style-type: none"> <li>▫ Finite difference method (FDM)</li> <li>▫ Energy Methods (Ritz, Galerkin)</li> <li>▫ Finite element method (FEM)</li> <li>▫ Multi body dynamics (MBS)</li> </ul> </li> <li>▪ Computational analysis of selected problems in biomechanics</li> </ul>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: re-working of lectures, autonomous execution of exercises, preparation of the exam
Frequency	Every winter semester
Duration	One 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
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
Responsible person	apl. Prof. Dr.-Ing. habil. Gabor Janiga (FVST - LSS)

# Computed Tomography

Teaching	Lecture, Tutorial, Seminar, Lab project
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Examination	Written examination 120 min
Credit Points	10 CP = 300 h (126 h time of attendance + 174 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture, 1 SWS Tutorial, 2 SWS Lab project
Frequency	Every summer semester
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

## Submodule: Methods on CT

Objectives and content	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"> <li>▪ understand the system theory of imaging systems</li> <li>▪ learn the functional principle of the computed tomography</li> <li>▪ understand the mathematical principle of tomographic reconstruction</li> <li>▪ have an overview about the current research work in the area of tomographic imaging</li> </ul> <p><b>Content:</b></p> <p>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:</p> <ul style="list-style-type: none"> <li>▪ System theory of imaging systems</li> <li>▪ Basic principle of underlying physics</li> <li>▪ X-ray tubes and detectors</li> <li>▪ Radiography</li> <li>▪ Reconstruction: Fourier-based principle, Filtered back projection, Algebraic approach, statistical methods</li> <li>▪ Beam-geometry: Parallel-, Fan- and Cone beam</li> <li>▪ Implementation</li> <li>▪ Artefacts and Adjustment</li> </ul>
Literature	Kak, Slaney: Principles of computerized tomographic imaging; Kalender: Computed Tomography
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate

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Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Rework of lectures and tutorial, preparation of exercises
Frequency	Every summer semester
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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### Submodule: Advances in CT

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Objectives and content	The student will: <ul style="list-style-type: none"><li>▪ get an overview over a variety of specialized CT topics</li><li>▪ understand current hot topics regarding CT-theory and application</li></ul> <p><b>Content:</b></p> Students will present their gathered knowledge of current CT topics in a presentation and discussion round.
Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 1 SWS Lecture Autonomous work: Preparation of presentation and discussion
Frequency	Every summer semester
Duration	One semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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### Sub-Module: Lab course CT

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Objectives and content	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"><li>▪ apply theoretical knowledge about computed tomography topics (e.g. from the module “Medical Imaging - Computed Tomography”)</li><li>▪ get a deeper understanding of the properties of data acquired by CT scanners</li><li>▪ learn to assert image quality</li><li>▪ practice processing CT dataset and reconstruction in MATLAB (or C/C++)</li><li>▪ be stimulated to think about alternative methods to solve problems analytically</li></ul> <p><b>Content:</b></p> <p>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).</p> <p>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.</p> <p>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.</p>
Literature	Buzug, Thorsten: Computed Tomography: From Photon Statistics to Modern Cone-Beam CT
Teaching	Lab project
Prerequisite for the admission to any examination	Lab certificate
Work load	<p>Time of attendance: 2 SWS Lab project</p> <p>Autonomous work:</p> <ul style="list-style-type: none"><li>▪ 1/6 - theoretical preparation (literature research)</li><li>▪ 1/6 - performing the measurement resp. theoretical analysis</li><li>▪ performing the measurement resp. theoretical analysis</li><li>▪ 1/3 - implementation of the routines</li><li>▪ 1/6 - evaluation and visualization</li><li>▪ 1/6 - preparing a talk or report</li></ul> <p>The full lab course has to be done in autonomous work</p>
Frequency	Every summer semester
Duration	One semesters
Responsible person	Dr.-Ing. Tim Pfeiffer (FEIT-IMT))

# Computer Assisted Surgery

Objectives and content	<p><b>Objectives:</b></p> <p>Computer-assisted surgery is an interdisciplinary research field that builds a bridge between surgery and computer science. It represents a set of methods which use computer technology to support preoperative planning, the actual surgery, and postoperative assessment. This lecture will offer an overview of computer-assisted surgery. After an introduction of fundamentals, the state of the art in computer-assisted surgery is presented on the basis of clinical examples.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of Intraoperative Imaging</li> <li>▪ Fundamentals of Surgical Visualization</li> <li>▪ Computer-Assisted Surgery Planning</li> <li>▪ Surgical Navigation Systems</li> <li>▪ Surgical Augmented Reality</li> <li>▪ Surgeon-Computer Interaction</li> <li>▪ Robotic Surgery</li> <li>▪ Development and Evaluation of Medical Software</li> </ul>
Literature	
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Oral Examination
Credit Points	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	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ The participant has an overview of basic problems and methods of digital signal processing.</li> <li>▪ The participant understands the functionality of a digital signal processing system and can mathematically explain the modus of operation.</li> <li>▪ The participant can assess applications in terms of stability and other markers. He / She can calculate the frequency response and reconstruction of analogue signals.</li> <li>▪ The participant can perform these calculations and assessments as well on stochastically excited digital systems.</li> <li>▪ The participant can apply this knowledge in a field of specialization, e. g. Medical Signal Analysis</li> </ul> <p><b>Content:</b></p> <ol style="list-style-type: none"> <li>1. Digital Signals and Digital LTI Systems</li> <li>2. Z-Transform and Difference Equations</li> <li>3. Sampling and Reconstruction</li> <li>4. Synthesis and analysis of such systems</li> <li>5. Discrete and Fast Fourier Transformations</li> <li>6. Processing of Stochastic Signals by LTI-Systems: Correlation Techniques and Model-Based Systems (ARMA)</li> <li>7. Selected Specialization Topics, e. g. Medical Signal Analysis</li> </ol>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies Knowledge of signals and systems, Analog Fourier transformations
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 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	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ The participant has an overview of basic methods of applied digital signal processing.</li> <li>▪ The participant can transform physiological knowledge into technical digital signal processing methods.</li> <li>▪ Selected Feature Space transformations and their applications are known.</li> <li>▪ Gaussian Production System Architectures are being estimated under Maximum-Likelihood Assumptions</li> </ul> <p><b>Content:</b></p> <ol style="list-style-type: none"> <li>1. Digital Signals and Digital LTI Systems</li> <li>2. Synthesis and analysis of such systems</li> <li>3. Discrete and Fast Fourier Transformations</li> <li>4. Selected Feature Space transformations</li> <li>5. Gaussian Production System Architectures</li> <li>6. Characteristics of Human Speech</li> </ol>
Literature	
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 (EMC)

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



# Entwicklung von Medizinprodukten

Objectives and content	<p><b>Ziel:</b></p> <p>Überblick über die grundlegenden regulatorischen und fachlichen Voraussetzungen für die Entwicklung und das Inverkehrbringen von Medizinprodukten in Deutschland und Europa.</p> <p><b>Fach- und methodische Kompetenz:</b></p> <p>Studenten können europäische rechtliche Bestimmungen benennen und deren Auswirkungen für den Standort Deutschland konkretisieren. Sie können einzelne Entwicklungs- und Zertifizierungsschritte des Produktlebenszyklus beschreiben und Medizinprodukte entsprechend dem MPG zuordnen. Grundlegende Methoden des produktbezogenen Risikomanagement können erläutert und am Beispiel von Medizingerätesoftware vorgestellt werden.</p> <p><b>Einbindung in die Berufsvorbereitung:</b></p> <p>Das Modul liefert wichtige Impulse für spätere Arbeitsbereiche, wie z.B. Planung von Entwicklungsschritten, Risikomanagement, Qualitätsmanagement und Konformitätsprüfung.</p> <p><b>Inhalt:</b></p> <p>Definition Medizinprodukt, MDR, Europäische Richtlinien, Harmonisierung, Klassifizierung von MP, Benannte Stellen, Produktlebenszyklus, Zweckbestimmung, Konformitätserklärung und CE-Kennzeichnung, Qualitätsmanagement (13485), Risikomanagement (14971), FTA, FMEA, Entwicklungsprozesse, Softwareentwicklung, Gebrauchstauglichkeit</p>
Literature	
Teaching	Vorlesung, Übung
Prerequisites	Grundlagen Software-Entwicklung
Recommended prerequisites	Keine
Applicability of the module	Masterprogramm
Prerequisite for the admission to any examination	Keine
Examination	Seminararbeit
Credit Points	5 CP = 150 h (60 h Anwesenheit + 90 h individuelle Arbeit)
Work load	2 SWS Vorlesung, 1 SWS Übung
Frequency	Jedes Sommersemester
Duration	Ein Semester
Responsible person	Prof. Dr. Thomas Neumuth (ICCAS Leipzig)

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

Objectives and content	<p><b>Objectives:</b></p> <p>This module comprises a seminar and a lab project. In the seminar, students will learn how concepts and methods borrowed from engineering have provided fundamental insight into principles of human motor control. Following a brief introduction to the anatomy and physiology of the human motor system, students will become familiar with important challenges and problems in human motor control, as well as approaches to solve them. They will read, and learn to summarize, present, and critically review, selected seminal experimental research in this field. In the lab project, students will learn to apply several key methods used in human neuroscience. They will acquire knowledge about the acquisition, visual inspection and analysis of electroencephalographic (EEG) signals, learn appropriate algorithms for feature extraction and classification, and become familiar with basic problems of brain-computer-interfaces (BCI). At the end of the lab project, they will be able to process the discussed problems by autonomously applying the learned algorithms. Competing for the best performance in an EEG-data decoding task, students will be able to deepen their knowledge and skills in a research oriented way and to apply and evaluate it on complex problems.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Introduction/Theoretical background: <ul style="list-style-type: none"> <li>▫ Anatomy and physiology of the human motor system</li> <li>▫ Fundamental problems in human motor control, and concepts and methods borrowed from engineering to solve them</li> <li>▫ Basic principle BCI</li> <li>▫ EEG</li> <li>▫ Feature extraction</li> <li>▫ Classification</li> <li>▫ Steady State Visually Evoked Potentials (SSVEP)</li> </ul> </li> <li>▪ Critical scientific reading, introduction to the human motor neuroscience</li> </ul>
Literature	<p>[1] Nicolas-Alonso and Gomez-Gi (2012). Brain-computer interfaces, a review. <i>Sensors</i> 12(2):1211-79.</p> <p>[2] Vialatte et al. (2010). Steady-state visually evoked potentials: focus on essential paradigms and future perspectives. <i>Prog Neurobiol.</i> 90(4):418-38.</p>
Teaching	Seminar, Lab Project
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation / Programming task
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 1 SWS Seminar, 2 SWS Lab Project Autonomous work: Preparation of the seminars and the exam, preparation and solving of programming lab tasks
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. med. Max-Philipp Stenner (FME-KNEU)

# Finite Element Method

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of the boundary value problem in solid mechanics</li> <li>▪ Variation calculus and weak form</li> <li>▪ FE discretization and shape functions</li> <li>▪ Isoparametric truss elements</li> <li>▪ Plane finite elements</li> <li>▪ Volume elements</li> <li>▪ Extended element technology</li> </ul>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Good skills in mechanics and mathematics
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Postprocessing of lectures, preparation of exercises and exam
Frequency	Every winter semester
Duration	One semesters
Responsible person	Jun.-Prof. Dr.-Ing. Daniel Juhre (FMB-IFME)

# Human-Computer Interfaces in Medicine

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

# Hybrid Imaging

Objectives and content	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ Understanding for the fundamental principles and limitations of hybrid imaging</li> <li>▪ Knowledge of the main applications and advantages compared to single modalities</li> <li>▪ Knowledge of the characteristics of human tissues and their visualisation by imaging techniques</li> <li>▪ Knowledge on the specific problems of combined modalities</li> <li>▪ Understanding for the role of combined vs. individual imaging techniques</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ The clinical motivation for hybrid imaging</li> <li>▪ Basic principles of the hybrid concepts</li> <li>▪ The history of origin, first prototypes and the methodological and technical development of the individual modalities</li> <li>▪ 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)</li> <li>▪ 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.)</li> <li>▪ 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)</li> <li>▪ Compliance with the principles of radiation protection when applying and optimizing the methods.</li> <li>▪ The development of imaging artifacts and their systematic influence on hybrid imaging.</li> <li>▪ New detector technologies and their methodological developments.</li> <li>▪ New (potential) hybrid imaging concepts (e.g. US in combination with CT), basic ideas and potential developments</li> </ul>
Literature	
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	<p><b>Objectives:</b></p> <p>Learn about methods and techniques of image coding as essential part in image communication. Problems of image acquisition are treated as far as relevant for image coding. Applications of image coding algorithms in image compression standards and their use in selected fields such as medical imaging are discussed.</p> <p>At the end of the course the students are able to assess existing coding methods for still images and video. They know relevant problems of image acquisition and representation, how the information content in images can be estimated and learn principles in the design of encoders for image and video compression. Students are able to apply image coding methods in medical applications.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Acquisition and representation of images</li> <li>▪ Human perception</li> <li>▪ Image forming systems</li> <li>▪ Information theory</li> <li>▪ Quantisation</li> <li>▪ Data compression</li> <li>▪ Lossy coding</li> <li>▪ Video compression</li> <li>▪ Transform coding</li> <li>▪ Content based and semantic coding</li> <li>▪ Standards and applications</li> </ul>
Literature	Many literature on image and video compression is helpful but doesn't replace necessity of being present at classes, e. g. John W. Woods: Multidimensional signal, image, and video processing and coding, Academic Press, 2012, (Online available), material for lecture and exercise is provided by e-learning system
Teaching	Lecture, Tutorial
Prerequisites	Modules typical for Bachelor in Electrical Engineering or related courses
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, solving tasks of exercises, preparation of presentation, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Dr.-Ing. Gerald Krell (FEIT-IIKT)

# Introduction in Tissue Engineering

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of cell biology and cell culture technology</li> <li>▪ Biological methods to characterize cellular function</li> <li>▪ Basic principles of tissue engineering</li> <li>▪ 3D tissue models and their application</li> </ul>
Literature	Review article will be provided
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 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	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ confidently apply DL techniques to develop a solution for a given problem</li> <li>▪ follow recent DL publications and critically assess their contributions</li> <li>▪ formulate hypotheses and design and conduct DL experiments to validate them</li> <li>▪ document progress and design decisions for reproducibility and transparency</li> <li>▪ for Master: advanced competencies in scientific research in topics of the module</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ artificial neural network fundamentals (gradient descent and backpropagation, activation functions)</li> <li>▪ network architectures (Convolutional Neural Networks, Recurrent/Recursive Neural Networks, Auto-Encoders)</li> <li>▪ regularization techniques</li> <li>▪ introspection and analysis techniques</li> <li>▪ optimization techniques</li> <li>▪ advanced training strategies (e.g. teacher-student)</li> </ul>
Literature	Ian Goodfellow, Yoshua Bengio and Aaron Courville: "Deep Learning", MIT Press, 2016
Teaching	Lecture, Tutorial
Prerequisites	Machine learning for Medical Systems, Number of participants limited, Only for students with excellent knowledge in signal processing, mathematics and machine learning
Recommended prerequisites	<ul style="list-style-type: none"> <li>▪ linear algebra and probability theory</li> <li>▪ machine learning (e.g. "Intelligente Systeme" or "Machine Learning")</li> </ul>
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	10 CP = 300 h (84 h time of attendance + 216 h self-study)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial (theory exercise), 2 SWS Tutorial (practice exercise)
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Sebastian Stober (FIN-IKS)



# Introduction to Probability and Statistics

Objectives and content	<p><b>Objectives:</b></p> <p>The students:</p> <ul style="list-style-type: none"> <li>▪ acquire basic knowledge of descriptive statistics for univariate data and for analysing simple relationships,</li> <li>▪ develop the ability to analyse data using appropriate tools,</li> <li>▪ are able to compute probabilities for some standard distributions,</li> <li>▪ understand how real world problems can be modelled by using probabilistic concepts.</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Variables and measurement levels</li> <li>▪ 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)</li> <li>▪ Elementary probability concepts, discrete and continuous random variables, probability distributions, probability density function and cumulative distribution function</li> <li>▪ Theoretical measures of location and variability (expected value, variance, standard deviation, quantiles)</li> <li>▪ Statistical independence, conditional probability, Bayes theorem</li> <li>▪ Special distributions: Bernoulli, Binomial, Poisson, continuous uniform, exponential and normal distributions</li> <li>▪ Law of large numbers, central limit theorem</li> <li>▪ Simple concepts for relationships: contingency tables and Pearson correlation</li> </ul>
Literature	Newbold, P.; Carlson, W.; Thorne, B. (2013): Statistics for Business and Economics. 8 th edition, Pearson: Harlow.
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)

# Introduction to Programming Techniques in Engineering

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Fundamentals of Python programming</li> <li>▪ Data manipulation and representation</li> <li>▪ Scientific calculations</li> <li>▪ Interactive graphical user interface (GUI)</li> <li>▪ Arduino programming platform</li> <li>▪ Arduino hardware development</li> </ul>
Literature	Online resources on Python and Arduino
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 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)

# Introduction to the approval process of medical devices

Objectives and content	<p><b>Objectives:</b></p> <p>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 elective module, we want to arouse students' interest in these regulatory affairs topics in the modules including active participation of representatives of the medical device industry. We want to teach the essential basics for an activity in the regulatory environment. In the first semester, we will address the process as whole as well as regulatory and structural requirements.</p> <p><b>Content:</b></p> <p>The content is based on the specifications for the European CE approval and relevant DIN ISO specification. It includes the following topics:</p> <ul style="list-style-type: none"> <li>▪ Introduction to the process of market approval</li> <li>▪ GxPractice and alternative</li> </ul> <p>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.</p>
Literature	Will be made available digitally at the beginning of the course
Teaching	Lecture, Seminar
Prerequisites	None
Recommended prerequisites	Attending the module Basics for Medical Device Approval of MT Bachelor (OvGU) is an advantage
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	Prof. Dr. rer. biol. Heike Walles (FVST - ICH)

# Introduction to the pre- market phase in the approval process of medical devices

Objectives and content	<p><b>Objectives:</b></p> <p>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 the differences between international admission procedures in this module.</p> <p><b>Content:</b></p> <p>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.</p>
Literature	
Teaching	Lecture, Seminar
Prerequisites	Attending the module Introduction to the approval process of medical devices
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 winter semester
Duration	One semester
Responsible person	Dr. Karim Djamshidi (Executive Director Global Regulatory Affairs - KARL STORZ SE and Co. KG), Prof. Dr. rer. biol. Heike Walles

# Machine Learning for Medical Systems

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

# Master Thesis

Objectives and content	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"> <li>▪ Create a research-oriented scientific dissertation</li> <li>▪ Master the writing of a scientific report in the extent of a Master thesis with high scientific standard</li> <li>▪ be able to defend and present her/his own work and to answer questions scientifically</li> </ul> <p><b>Content:</b></p> <p>according to prior agreement with the examiner(s)</p>
Literature	
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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ n-dimensional Euclidean space</li> <li>▪ Matrix algebra</li> <li>▪ Solving linear equations</li> <li>▪ Eigenvalues and -spaces</li> <li>▪ Simple examples of ordinary differential equations</li> <li>▪ Functions in several variables</li> <li>▪ Optimization of functions in several variables</li> </ul>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work: Preparing for tutorials and solving homework assignments, 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	<p><b>Objectives:</b></p> <p>The student will</p> <ul style="list-style-type: none"> <li>▪ learn methods for mathematical modeling of physiological systems</li> <li>▪ from 1st principles based on fundamental physical and chemical relations</li> <li>▪ learn different methods and tools for computer simulation of physiological system with application to selected subsystems</li> <li>▪ gain a fundamental understanding of the dynamics of the considered subsystems by means of targeted simulation experiments</li> <li>▪ be able to transfer the methodology to other physiological systems in the frame of future research projects</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ cardio vascular system</li> <li>▪ control of cell volume and electrical properties of cell membranes</li> <li>▪ signal transduction in nerve cells</li> <li>▪ signal transduction in the retina</li> <li>▪ signal transduction in the ear/ ear implants</li> <li>▪ population balance modelling of cellular systems</li> </ul>
Literature	<p>[1] Hoppensteadt, F.C.; Peskin, C.S.: Modeling and Simulation in Medicine and the Life Sciences, Springer, Berlin, 2002.</p> <p>[2] Keener, J.; Sneyd, J.: Mathematical Physiology, Springer, Berlin, 1998.</p>
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	<p><b>Objectives:</b></p> <p>The lecture addresses two main topics:          The students acquire knowledge of the fundamentals of <b>chemical and biological sensors</b> 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 <b>ultrasonic sensors</b>, 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.</p> <p><b>Content:</b></p> <p><b>Chemical and biological sensors</b></p> <ul style="list-style-type: none"> <li>▪ Introduction</li> <li>▪ Transduction Phenomena</li> <li>▪ (Bio-)Chemical Sensor Characteristics</li> <li>▪ Electrochemical Sensors and Biosensors</li> <li>▪ Optical Sensors</li> <li>▪ Acoustic Sensors</li> </ul> <p><b>Ultrasonic sensors for imaging</b></p> <ul style="list-style-type: none"> <li>▪ Principles of generation and detection of ultrasound</li> <li>▪ Fundamentals of acoustic wave propagation</li> <li>▪ Methods of signal optimization and signal extraction</li> <li>▪ New trends in ultrasonic sensor development and imaging principles</li> </ul>
Literature	<p>[1] Peter Gründler, Chemical Sensors An Introduction for Scientists and Engineers, Springer Link</p> <p>[2] Ghenadii Korotcenkov: Chemical Sensors, Vol 1: General Approaches (Sensor Technology), Momentum press 2010</p> <p>[3] J. Fraden, Chemical and Biological sensors, Chapter 18 from Handbook of Modern Sensors (pp 645-697)</p> <p>[4] Florinel-Gabriel Banica: Chemical Sensors and Biosensors: Fundamentals and Applications, Wiley &amp; Sons, by John Wiley &amp; Sons, Ltd</p> <p>[5] Watson, J., Chemical Sensors 1-6, Momentum Press 2010.</p> <p>[6] Sanches, J.M., Ultrasound Imaging: Advances and Applications, Springer 2012, dx.doi.org/10.1007/978-1-4614-1180-2.</p> <p>[7] Scabo, T.L., Diagnostic Ultrasound Imaging, Elsevier, 2007.</p>
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 (56 h time of attendance + 94 h autonomous work)

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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)

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# Medical Visualization

Objectives and content	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ An understanding of medical diagnosis and treatment with 3D volume data</li> <li>▪ An understanding of perceptual issues in interpreting medical volume data, presented in 2D and 3D displays</li> <li>▪ An understanding of user needs in selected diagnostic and treatment planning tasks</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Introduction to medical image processing and analysis</li> <li>▪ Surface rendering of medical volume data</li> <li>▪ Web-based 3D visualization of medical volume data</li> <li>▪ Volume rendering</li> <li>▪ Advanced transfer functions</li> <li>▪ Visualization of vascular structures</li> <li>▪ Virtual endoscopy</li> <li>▪ Illustrative medical visualization</li> <li>▪ Interaction techniques with 3D visualizations of medical volume data</li> <li>▪ Visual exploration of blood flow data</li> </ul> <p>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.</p>
Literature	Bernhard Preim, Charl P Botha. Visual Computing for Medicine, Second Edition: Theory, Algorithms, and Applications , Morgan Kaufmann, 2013
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120 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: 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	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ Understanding of magnetic resonance principle</li> <li>▪ Knowledge of spatial encoding in MR</li> <li>▪ Knowledge of different MR measurement methods</li> <li>▪ Understanding of MR reconstruction principles</li> <li>▪ Understanding of physical and technical possibilities and limitations</li> <li>▪ Ability to apply knowledge for simple modifications of MR sequences</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ MR signal generation</li> <li>▪ MR signal evolution (Bloch equation)</li> <li>▪ MR measurement parameters</li> <li>▪ Spatial encoding</li> <li>▪ MR measurement methods (sequences)</li> <li>▪ MR reconstruction</li> </ul>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering, physics or related subjects, Basics of physics, mathematics and imaging systems
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 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	<p><b>Objectives:</b></p> <p>The student will:</p> <ul style="list-style-type: none"> <li>▪ be trained in basic fluid mechanics and the particularities of flows on micro- scopic spatial scales</li> <li>▪ learn about areas of applications of microfluidics</li> <li>▪ obtain solutions from simple numerical techniques</li> <li>▪ compare analytical solutions with numerical solutions to experience limits and possibilities of computational fluid mechanics</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Basic concepts in microfluidics</li> <li>▪ Simple flows <ul style="list-style-type: none"> <li>▫ Hydrostatics</li> <li>▫ Couette and Poiseuille flows</li> <li>▫ Stokes Drag</li> </ul> </li> <li>▪ Microfluidic network analysis (hydraulic resistance and compliance)</li> <li>▪ Capillarity</li> <li>▪ Electro hydrodynamic <ul style="list-style-type: none"> <li>▫ Electroosmosis</li> <li>▫ Dielectrophoresis</li> </ul> </li> <li>▪ Selected flows in microfluidics</li> <li>▪ Hele-Shaw geometry</li> <li>▪ Multiphase flows</li> <li>▪ Gas bubbles and droplet</li> <li>▪ Acoustofluidics</li> </ul>
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering, physics or related subjects, Basics of physics, mathematics and imaging systems
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 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: 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)

# MRI Pulse Sequence Design

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Basic MR physics (excitation, signal, Bloch equations, T1, T2)</li> <li>▪ MR instrumentation (magnet; transmission: RF system, gradient system; receiving: receiving coil, gradient system - readout gradient, ADC; digital MR signal processing)</li> <li>▪ MR image encoding/reconstruction</li> <li>▪ MR pulse sequences (MR#, SketchMR)</li> <li>▪ MR simulation</li> <li>▪ Inverse problems in MR image reconstruction</li> </ul>
Literature	<p>[1] Spin Dynamics: Basics of Nuclear Magnetic Resonance. 2nd Edition. Wiley, 2008</p> <p>[2] Understanding NMR Spectroscopy. 2nd Edition. Wiley, 2010</p> <p>[3] Handbook of MRI Pulse Sequences. Academic Press, 2004</p>
Teaching	Seminar
Prerequisites	Basics of Magnetic Resonance (by Prof. Dr. rer. nat. habil. Oliver Speck)
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	<p>Time of attendance: 3 SWS Seminar</p> <p>Autonomous work: Follow-up and preparation of the seminar, preparation of the seminar work</p>
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. rer. nat. Stefan Roell (Neoscan Solutions GmbH)

# MR System Engineering

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ MRI basics</li> <li>▪ MRI scanner system architecture</li> <li>▪ MRI software architecture, sequence and measurement protocols</li> <li>▪ MRI system hardware components</li> <li>▪ Group projects</li> </ul> <p>The maximum number of participating students is restricted to 16.</p>
Literature	Magnetic Resonance Imaging - Physical Principles and Sequence Design, Robert W. Brown, ISBN-10: 3800733056
Teaching	Lecture, Tutorial
Prerequisites	None
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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ The basic elements of matter</li> <li>▪ Decay processes</li> <li>▪ Radiation therapy with radioisotopes</li> <li>▪ Decay processes</li> <li>▪ Radiation therapy with radioisotopes</li> <li>▪ Brief overview on medical imaging with radioisotopes</li> <li>▪ Tracers principle and development, medical relevant nuclides</li> <li>▪ Production and quality control of radiopharmaceuticals</li> <li>▪ Specific tasks for radiation protection</li> <li>▪ Theranostic principle and personalized therapy</li> <li>▪ Legal aspects (radiation protection vs. pharmaceutical production)</li> </ul>
Literature	<p>[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</p>
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	<p>Time of attendance: 2 SWS Lecture, 1 SWS Exercise, 2 SWS Laboratory course (block course in semester break)</p> <p>Autonomous work: Rework of lectures and exercises, preparation of exercises, preparation and review of the laboratory course</p>
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. C. Hoeschen (FEIT-IMT), Dr. E. Eppard (FME), Dr. A. Hohn (FME)



# Pharmacokinetic and Pharmacodynamic Modeling

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Introduction into pharmacokinetic and pharmacodynamic modeling</li> <li>▪ Pharmacokinetic and pharmacodynamic parameters</li> <li>▪ Fundamentals for modeling biological and medical systems</li> <li>▪ Constitutive equations and transport phenomena</li> <li>▪ Numerical methods for solving differential equations</li> <li>▪ Methods for optimal experimental design</li> </ul>
Literature	P. Macheras, A. Iliadis "Modeling in Biopharmaceutics, Pharmacokinetics and Pharmacodynamics: Homogeneous and Heterogeneous Approaches"
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 Facht (FEIT-IMT)

# Planar Medical Imaging Techniques

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ol style="list-style-type: none"> <li>1. X-ray projection radiography             <ol style="list-style-type: none"> <li>a) Absorption</li> <li>b) Dark field</li> <li>c) Phase contrast</li> </ol> </li> <li>2. Optical imaging             <ol style="list-style-type: none"> <li>a) Microscopy</li> <li>b) Infrared</li> <li>c) Coherence</li> </ol> </li> <li>3. Ultrasound and impedance imaging</li> <li>4. Examples for molecular imaging             <ol style="list-style-type: none"> <li>a) Magnetic nanoparticle imaging</li> <li>b) Scintigraphy</li> </ol> </li> </ol>
Literature	<p>[1] Diakides, Medical Infrared Imaging - Principles and Practices (2012)</p> <p>[2] Plonsey, Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields (1995)</p> <p>[3] Paganin, Coherent X-ray Optics (2006)</p> <p>[4] Scherer, Grating based X-ray phase contrast mammography (2016)</p> <p>[5] Bushberg, The Essential Physics of Medical Imaging (2011)</p> <p>[6] Oppelt, Imaging systems for medical diagnostics (2005)</p>
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	<p><b>Objectives:</b></p> <p>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 fundamentals 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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Physical principles of PET</li> <li>▪ Modern reconstruction algorithms for PET</li> <li>▪ New CMOS sensors and digital electronics</li> <li>▪ Physical aspects of NEMA standards</li> <li>▪ Pre-clinical, clinical, brain and proton therapy monitoring PET systems</li> <li>▪ Radiomics in PET imaging</li> </ul>
Literature	D. L. Bailey, D. W. Townsend, P. E. Valk, M. N. Maidey, Positron Emission Tomography, Springer, 2005.
Teaching	Lecture, Tutorial
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <p>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.</p>
Literature	
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 winter semester
Duration	One semester
Responsible person	Dr. Melanie Facht (FEIT-IMT), Sinja Lagotzki (InLine-Med GmBH), Daniel Gwinner (Neoscan Solutions GmbH)

# Research Project

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <p>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:</p> <ul style="list-style-type: none"> <li>▪ Design and development of medical hardware (e.g. electronic circuits)</li> <li>▪ Design and development of dedicated algorithms/ software for medical technology</li> <li>▪ Design and development of simulators or prototypes (software or hardware)</li> <li>▪ Development of specific solutions in the field of imaging and image processing (e.g. x-ray, CT, MRI, PET, US)</li> </ul> <p>The exact task will be defined in consultation with the respective supervisor according to the interests of the student.</p>
Literature	Depending on the research project
Teaching	None
Prerequisites	Completion of all compulsory modules of the first semester; proactive personality; excellent academic performance during Bachelor and current Master; detailed 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

# Rheologie und Rheometrie

Objectives and content	<p><b>Objectives:</b></p> <p>Die Mehrzahl aller fluiden Stoffe mit denen wir umgeben sind, weisen nicht-Newtonsche Eigenschaften auf. Das Fliessverhalten dieser Stoffe spielt in der Produktions- und Anwendungstechnik, der Qualitätssicherung, der Materialforschung und -entwicklung eine zentrale Rolle. Mit der Vorstellung rheologischer Phänomene beginnend, werden die physikalischen Eigenschaften wie Viskosität und Elastizität erläutert. Daran schliesst sich eine Einteilung und die mathematische Beschreibung der rheologischen Zustandsgleichungen der Medien an. Einfache laminare rheologische Strömungen werden vorwiegend behandelt. Aktuelle Messmethoden und abgeleitete Modelle bilden einen Schwerpunkt der Vorlesung. Nach der Teilnahme an diesem Modul beherrschen die Studenten alle grundsätzlichen Konzepte, die für die Beschreibung komplexer Fluide notwendig sind. Sie kennen die charakteristischen Eigenschaften nicht-Newtonscher Fluide sowie ihre volkswirtschaftliche Bedeutung und die wichtigsten Einsatzgebiete. Sie sind in der Lage, komplexe Stoffverhalten zu identifizieren, charakterisieren, interpretieren und in theoretische/numerische Modelle einfließen zu lassen.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Grundlagen der Rheologie, Teilgebiete, rheologische Phänomene (Begriffe und Definitionen, Verhalten bei angelegter Spannung, elastische Körper und viskose Körper)</li> <li>▪ Physikalische Grundlagen, Erhaltungssätze</li> <li>▪ Einfache Deformationsformen</li> <li>▪ Rheologische Messprinzipien, Geräte und Methoden (stationäre Methoden, instationäre Methoden, Rheometertypen, Messung anderer rheologischer Parameter)</li> <li>▪ Klassifizierung. Ideale Körper: Newtonsche, Hookesche -Körper; Nicht-Newtonsche zähe Flüssigkeiten: rheostabile, -dynamische, viskoelastische Flüssigkeiten</li> <li>▪ Methoden zur Aufstellung der Fließfunktion (Approximation der Fließkurve, halbtheoretische Ansätze, mechanische Modelle)</li> <li>▪ Einfluss von Temperatur, Druck, Zusammensetzung</li> <li>▪ Ingenieurtechnische Anwendungen (insbesondere Spaltströmung, Rohrströmung)</li> <li>▪ Blut-Rheologie</li> </ul>
Literature	G. Böhme: Strömungsmechanik nichtnewtonscher Fluide, Teubner Verlag
Teaching	Vorlesung, Übung
Prerequisites	Strömungsmechanik, Mechanik
Recommended prerequisites	Keine
Applicability of the module	Masterprogramm
Prerequisite for the admission to any examination	Keine
Examination	Schriftliche Prüfung 90 min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	2 SWS Vorlesung, 1 SWS Übung
Frequency	Jedes Wintersemester
Duration	Ein Semester
Responsible person	Prof. Dr.-Ing. habil. Dominique Thevenin (FVST - LSS)

## Scientific Working

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Prepare 20 min presentation based on the per-reviewed scientific paper from reputable journal.</li> <li>▪ Prepare video with his/her delivery of the presentation.</li> <li>▪ Review presentations of 2 other people.</li> <li>▪ Respond to the reviewers regarding his/her own presentation.</li> <li>▪ Deliver the presentation/prepare final video.</li> <li>▪ Evaluate final presentation of two other students.</li> </ul>
Literature	
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation 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 Facht (FEIT-IMT)

# Soft Matter and Microfluidics Lab

Objectives and content	<p><b>Objectives:</b></p> <p>The participant will:</p> <ul style="list-style-type: none"> <li>▪ be trained in the design, planning and conduction of experiments concerning soft matter and fluids</li> <li>▪ autonomously design and produce parts of the experimental setup</li> <li>▪ work out theoretical background and relationships of the experiment</li> <li>▪ prepare a scientific lab report and give an oral presentation summarizing theory, experimental strategy, and critically discussing the results</li> </ul> <p><b>Content:</b></p> <p>Experiments on the following topics:</p> <ul style="list-style-type: none"> <li>▪ design and production of microfluidic systems with lithographic and maskless methods (3D FDM printing, laser cutting, stereo lithography)</li> <li>▪ micro-particle tracking and velocimetry for flow analysis</li> <li>▪ measurement of diffusion coefficient with optical methods</li> </ul> <p>Design and conduction of one experiment chosen among:</p> <ul style="list-style-type: none"> <li>▪ electro-osmosis</li> <li>▪ non-linear acoustics, acoustic streaming and acoustophoresis</li> <li>▪ t-channel droplet generator</li> <li>▪ non-linear bubble oscillator and sonoluminescence</li> <li>▪ aerosol generation and acoustic levitation</li> <li>▪ ferrofluidics</li> </ul>
Literature	
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	<p><b>Objectives:</b></p> <p>The students will:</p> <ul style="list-style-type: none"> <li>▪ learn to propose and design a medical engineering related project.</li> <li>▪ learn about design methodology and previous successful student projects.</li> <li>▪ be introduced to using 3D design software to draw items which are needed for their projects.</li> <li>▪ get to use the Arduino platform to work on small projects in the class.</li> <li>▪ be introduced to making Android phone App.</li> <li>▪ present their project to the class and demonstrate its functionalities.</li> <li>▪ make a website or blog about their project.</li> </ul> <p><b>Content:</b></p> <p>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.</p>
Literature	
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Seminar presentation
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Seminar Autonomous work: Preparation of the seminars and lab project, preparation of the presentation
Frequency	Every semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

# Theoretical Neuroscience I

Objectives and content	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <p><b>Neuroelectronics (Chapters 5 and 6 of D&amp;A):</b> 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.</p> <p><b>Encoding and decoding (Chapters 1 to 4 of D&amp;A):</b> 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.</p>
Literature	<p>[1] Dayan &amp; Abbott, "Theoretical Neuroscience", 2001</p> <p>[2] Sterrat, Graham, et al., "Principles of Computational Modeling in Neuroscience", 2011</p>
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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <p><b>Network models (Chapter 7 of D&amp;A):</b> Rate models of network dynamics, linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states.</p> <p><b>Neural plasticity (Chapter 8 of D&amp;A):</b> Types of plasticity, activity-dependent plasticity, associative learning, models of neural development.</p> <p><b>Reinforcement learning (Chapter 9 of D&amp;A):</b> Conditioning, Rescorla-Wagner rule, temporal-difference learning, policy learning, actor-critic models.</p> <p><b>Representational learning (Chapter 10 of D&amp;A):</b> Generative models, K-means, expectation maximization, principal component analysis, sparse representations, independent component analysis.</p>
Literature	<p>[1] Dayan &amp; Abbott, "Theoretical Neuroscience", 2001</p> <p>[2] Wilson, "Spikes, Decisions and Actions: the Dynamical Foundations of Neuroscience", OUP 1999</p> <p>[3] Sutton &amp; Barto, "Reinforcement Learning: an Introduction", MIT 1999</p>
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	<p><b>Objectives:</b></p> <ul style="list-style-type: none"> <li>▪ Understanding the nature and importance of future user interfaces and the challenges and problems associated with them</li> <li>▪ Getting to know, analyzing and evaluating technologies, interaction techniques and methods for the development of advanced user interfaces</li> <li>▪ Ability to select suitable technologies and interaction techniques in the field of three-dimensional and modern Post-WIMP user interfaces</li> <li>▪ Ability to critically analyze scientific literature and knowledge of scientific publishing</li> <li>▪ Ability to conduct own research on a postgraduate level in the field of advanced user interfaces</li> </ul> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Introduction to Post-WIMP and Reality-based User Interfaces: 3D-Interaction Tasks, Devices, 3D-Widgets, 3D UIs</li> <li>▪ Augmented Reality Interaction</li> <li>▪ Pen-based Interaction Techniques and Sketching</li> <li>▪ Multitouch: Technologies, Gestures, Applications</li> <li>▪ Gestural Interaction: Tracking, Freehand Gestures</li> <li>▪ Tangible Interaction</li> <li>▪ Advanced Topics: Gaze-based Interaction, Organic Interfaces, Everywhere Interfaces</li> </ul>
Literature	<p>[1] Bowman, Kruijff, Laviola, Jr., Poupyrev: "3D User Interfaces: Theory and Practice", Addison-Wesley, 2004</p> <p>[2] Müller-Tomfelde (Ed.): "Tabletops - Horizontal Interactive Displays", Springer, 2010</p> <p>[3] Saffer: "Designing Gestural Interfaces", O'Reilly Media, 2008</p> <p>[4] Shaer, Hornecker: "Tangible User Interfaces: Past, Present and Future Directions". In Foundations and Trends in Human-Computer Interaction, 3 (1), 2010</p>
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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <p>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.</p>
Literature	
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	<p><b>Objectives:</b></p> <p>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.</p> <p><b>Content:</b></p> <ul style="list-style-type: none"> <li>▪ Overview: Potential and applications of Visual Analytics in Healthcare</li> <li>▪ Visual Analytics in Public Health</li> <li>▪ Visual Analytics in Clinical Medicine</li> <li>▪ Visual Analytics for Detecting Adverse Drug Effects</li> <li>▪ Visual Analytics in Epidemiology</li> </ul>
Literature	Workshop volumes of the IEEE Workshop Visual Analytics in Healthcare (since 2010), selected publications of other conferences / magazines in the fields of data analysis and visualization
Teaching	Seminar
Prerequisites	None
Recommended prerequisites	Visualization, Data Mining, Visual Analytics or Information Visualization
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
Credit Points	3 CP = 90 h (28 h time of attendance + 62 h autonomous work)
Work load	Time of attendance: 2 SWS Seminar
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Bernhard Preim (FIN-ISG)