OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
EIT FAKULTÄT FÜR ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Module descriptions

Master

Medical Systems Engineering

June 3, 2015

Contents

Advanced Security Issues in Medical Systems

Objectives and content	**Objectives:** The student will ▪ 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 ▪ be enabled to understand and devise application field specific IT security strategies **Content:** Selected current topics on technical, organizational, judicial, social and ethical topics, e. g.: ▪ Medical information systems ▪ Secure data storage and processing for person related and medical data ▪ Security in medical IT infrastructures: system-, network-, and application ▪ Special considerations for digital signal (image and audio) processing for medical records ▪ Security management in medical information systems ▪ Standardization, certification and evaluation of IT security for medical application scenarios and systems ▪ Case studies on IT security mechanisms and problems in medicine Seminar: ▪ Presence at three scheduled times ▪ Topic presentation distribution and registration ▪ Milestone presentation with structure and first, preliminary results ▪ Final presentation containing all results
Literature	For literature see http://omen.cs.uni-magdeburg.de/itiamsl/lehre/
Teaching	Seminar
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 summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Jana Dittmann (FIN-ITI)

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Analysis and modeling of Physiological Systems

Teaching	Lecture, Lab Project
Prerequisites	None
Applicability of the module	Master program
Examination	Oral examination ⚠Prüfung ohne Hilfsmittel
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance in winter semester: 2 SWS Lecture Time of attendance in summer semester: 1 SWS Lab Project
Frequency	Starts every winter semester
Duration	Two semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Sub-Module: Mathematical Modeling of physiological Systems

Objectives and content	**Objectives:** The student will ▪ learn methods for mathematical modeling of physiological systems ▪ from 1st principles based on fundamental physical and chemical relations ▪ learn different methods and tools for computer simulation of physiological ▪ system with application to selected subsystems ▪ gain a fundamental understanding of the dynamics of the considered subsystems by means of targeted simulation experiments ▪ be able to transfer the methodology to other physiological systems in the frame of future research projects **Content:** ▪ cardio vascular system ▪ control of cell volume and electrical properties of cell membranes ▪ signal transduction in nerve cells ▪ signal transduction in the retina ▪ signal transduction in the ear/ ear implants ▪ population balance modelling of cellular systems
Literature	[1] Hoppensteadt, F.C.; Peskin, C.S.:. Modeling and Simulation in Medicine and the Life Sciences, Springer, Berlin, 2002. [2] Keener, J.; Sneyd, J.: Mathematical Physiology, Springer, Berlin, 1998.
Teaching	Lecture
Prerequisite for the admission to any examination	None

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Work load	Time of attendance: 2 SWS Lecture 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)

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Sub-Module: Brain Computer Interfaces

Objectives and content	**Objectives:**
	At the end of the course, the students have knowledge about the acquisition, visual inspection and analysis of electroencephalographic (EEG) signals. The students learn appropriate algorithms for feature extraction and classification. With a successful completion of the module, the student have knowledge about basic problems of brain-computer-interfaces. (BCI) They are able to process the discussed problems by autonomously applying the learned algorithms. By programming of a computer game control via EEG-signals, the students are able to deepen their knowledge and skills in a research oriented way and to apply and evaluate it on complex problems
	Content:
	▪ Introduction/Theoretical background:
	  ▫ Basic principle BCI
	  ▫ EEG
	  ▫ Feature extraction
	  ▫ Classification
	  ▫ Steady State Visually Evoked Potentials (SSVEP)
	▪ Acquisition of EEG-signals
	▪ Artifact detection
	▪ Programming of a computer game control via SSVEP

Literature	
Teaching	Lab Project
Prerequisite for the admission to any examination	Lab certificate
Work load	Time of attendance: 1 SWS Lab Project ⚠wird als Blockveranstaltung durchgeführt Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Anatomy for Engineering students

Objectives and content	**Objectives:** ▪ Basic knowledge of anatomy and physiology of the central and peripheral nervous system ▪ Basic knowledge of anatomy and physiology of the human cardiovascular system ▪ Basic knowledge of the anatomy and physiology of the human musculoskeletal system ▪ Knowledge about the biomechanical properties of the structures/organs discussed ▪ Knowledge about the resulting consequences and requirements for medical devices and implants **Content:** ▪ The microscopic and macroscopic structure and function of the nervous system, the cardiovascular system and the musculoskeletal system ▪ Main focuses are the biomechanical properties and the functionality of the discussed structures and the links and application in biomedical engineering ▪ Relevant examples are: The elastic properties of blood vessels, haemodynamics, pulsatile flow, rigidity and plasticity of the bones and the kinematics of joints.
Literature	
Teaching	Seminar
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Written examination 60min
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 Lectures and Tutorials, Learning of the respective structures and functions
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Martin Skalej (FME-ZRAD-INR)

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Bayesian network

Objectives and content	**Objectives:** The student will ▪ learn basic concepts and methods of Bayesian Networks and related topics in the field of uncertainty ▪ understand and apply techniques to create Baysian Networks ▪ understand and apply data analysis methods to solve given problems ▪ have an overview of showcases applications and understand the basic functionality **Content:** ▪ Modeling of uncertainty and vagueness in expert systems ▪ Representation of uncertain information in probabilistic networks (Bayesian networks / Markov networks) ▪ Evidence propagation in such networks ▪ Quantitative and structural induction of probabilistic networks from data ▪ Other uncertainty calculi (Dempster-Shafer) ▪ Applications
Literature	[1] R. Kruse, C. Borgelt, F. Klawonn, C. Moewes, M. Steinbrecher, P. Held (2013). Computational Intelligence: A Methodological Introduction. Springer, New York. [2] C. Borgelt, M. Steinbrecher und R. Kruse (2009). Graphical Models - Representations for Learning, Reasoning and Data Mining, 2nd Edition. J. Wiley & Sons, Chichester, United Kingdom
Teaching	Lecture, Tutorial
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 (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 2 SWS Tutorial Autonomous work:
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. habil. Rudolf Kruse (FIN-IWS)

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Biological Statistics

Objectives and content	**Objectives:** The student will ▪ understand the fundamentals of statistics and probability theory ▪ have an overview about the standard methods of statistics ▪ learn to understand and interpret statistical results correctly ▪ be able to communicate statistical results ▪ and to transfer them back to real world problems **Content:** Central concepts of statistics and probability theory, insofar as relevant to medical systems engineering: ▪ descriptive statistics ▪ probability ▪ inferential statistics ▪ estimation and hypothesis testing ▪ analysis of variance ▪ correlation and regression ▪ general linear models ▪ non-parametric methods
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. habil. Rainer Schwabe (FMA-IMST)

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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
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Research project

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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:
Frequency	Every summer semester
Duration	One semester
Responsible person	Priv.-Doz. Dr.-Ing. Gabor Janiga (FVST-ISUT)

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Computed Tomography

Teaching	Lecture, Tutorial, Lab Project
Prerequisites	None
Applicability of the module	Master program
Examination	Written examination 120min
Credit Points	10 CP = 300 h (84 h time of attendance + 216 h autonomous work)
Work load	Time of attendance in winter semester: 2 SWS Lecture, 1 SWS Tutorial Time of attendance in summer semester: 1 SWS Lecture, 2 SWS Lab Project
Frequency	Starts every winter semester
Duration	Two semesters
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Sub-Module: Medical Imaging - Computed tomography

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

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Teaching	Lecture, Tutorial
Prerequisite for the admission to any examination	Tutorial certificate
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Rework of lectures and tutorial, preparation of excersices
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Sub-Module: Computed Tomography in Material Science

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

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Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. Lutz Hagner (Microvista GmbH)

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Sub-Module: Lab course CT

Objectives and content	**Objectives:** The student will: ▪ apply the theoretical knowledge from the sub-module "Medical Imaging - Computed Tomography" ▪ get a deeper understanding of the properties of data acquired by CT scanners ▪ learn to assert image quality ▪ practice processing CT dataset and reconstruction in MATLAB (or C/C++) ▪ be stimulated to think about alternative methods to solve problems analytically Required qualifications: ▪ sub-module "Medical Imaging - Computed Tomography" ▪ basic programming skills **Content:** The student has the choice between a practical task in the angiography lab including measurements and quantitative evaluation (angiography lab course), or to solve programming tasks with simulated data (computer lab course). Angiography lab course: The student will use a hardware performance phantom in order to evaluate the image quality of a clinical C-arm system. For this purpose, the student will perform measurements and export the data sets of the reconstructed images. For this, the student has to implement several routines to quantify the image quality. Finally, the results have to be analyzed and discussed. Computer lab course: The student will work on several programming tasks with different degrees of difficulty, covering a variety of typical problems in CT imaging. Usually, a data set consisting of simulated CT projections will be given. The task can be solved via an appropriate reconstruction or with creative analysis. Finally, the solution strategy has to be documented and discussed.
Literature	Buzug, Thorsten: Computed Tomography: From Photon Statistics to Modern Cone-Beam CT
Teaching	Lab Project
Prerequisite for the admission to any examination	Lab certificate

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Work load	Time of attendance: 2 SWS Lab Project Autonomous work: ▪ 1/6 - theoretical preparation (literature research) ▪ 1/6 - performing the measurement resp. theoretical analysis ▪ 1/3 - implementation of the routines ▪ 1/6 - evaluation and visualization ▪ 1/6 - preparing a talk or report The full lab course has to be done in an autonomous work.
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Computer Assisted Surgery

Objectives and content	**Objectives:** Computer-assisted surgery is an interdisciplinary research field that builds a bridge between surgery and computer science. It represents a set of methods which use computer technology to support preoperative planning, the actual surgery, and postoperative assessment. This lecture will offer an overview of computer-assisted surgery. After an introduction of fundamentals, the state of the art in computer-assisted surgery is presented on the basis of clinical examples. **Content:** ▪ Fundamentals of Intraoperative Imaging ▪ Fundamentals of Surgical Visualization ▪ Computer-Assisted Surgery Planning ▪ Surgical Navigation Systems ▪ Surgical Augmented Reality ▪ Surgeon-Computer Interaction ▪ Robotic Surgery ▪ Development and Evaluation of Medical Software
Literature	
Teaching	Seminar
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Seminar presentation
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Seminar Autonomous work:
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr. Christian Hansen (FIN-ISG)

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Development of Bio-MEMS for Medical Engineering

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

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Digital Information Processing

Objectives and content	**Objectives:** ▪ The participant has an overview of basic problems and methods of digital signal processing. ▪ The participant understands the functionality of a digital signal processing system and can mathematically explain the modus of operation. ▪ The participant can assess applications in terms of stability and other markers. He / She can calculate the frequency response and reconstruction of analogue signals. ▪ The participant can perform these calculations and assessments as well on stochastically excited digital systems. ▪ The participant can apply this knowledge in a field of specialization, e. g. Medical Signal Analysis **Content:** 1. Digital Signals and Digital LTI Systems 2. Z-Transform and Difference Equations 3. Sampling and Reconstruction 4. Synthesis and analysis of such systems 5. Discrete and Fast Fourier Transformations 6. Processing of Stochastic Signals by LTI-Systems: Correlation Techniques and Model-Based Systems (ARMA) 7. Selected Specialization Topics, e. g. Medical Signal Analysis
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies Knowledge of signals and systems, Analog Fourier transformations
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: postprocessing of lectures preparation of exercises and exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Andreas Wendemuth (FEIT-IIKT)

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Digital Information Processing Lab

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

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EMC of Medical Systems

Objectives and content	**Objectives:** The students gain information on the fundamental concepts, principles and measurement techniques of Electromagnetic Compatibility (EMC). At the end of the module they are able to understand and apply measures to improve EMC. They will be able to analyze the EMC of systems and know standard measurement procedures. The students know specific EMC demands of medical systems. **Content:** ▪ EMC regulation ▪ EM coupling, shielding, filtering ▪ EMC analysis ▪ Interference models for special applications ▪ EMC measures in electronic circuits ▪ Radiation hazards ▪ Measurement techniques
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
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:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Ralf Vick (FEIT-IMT)

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Functional Safety for Medical and Technical Systems

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

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Human-Computer Interfaces in Medicine

Objectives and content	**Objectives:** The aim of this seminar is to provide an overview about Human-Machine Interaction in medicine. In addition, students can train and improve their skills in scientific reading, presentation and discussion. **Content:** ▪ Human-Machine Interaction in Radiology ▪ Human-Machine Interaction in Surgery ▪ Usability Engineering for Medical Devices ▪ Clinical Evaluation of Human-Machine Interfaces
Literature	
Teaching	Seminar
Prerequisites	None
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:
Frequency	Every summer semester
Duration	One semester
Responsible person	Jun.-Prof. Dr. Christian Hansen (FIN-ISG)

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Image Coding

Objectives and content	**Objectives:** Learn about methods and techniques of image coding as essential part in image communication. Problems of image acquisition are treated as far as relevant for image coding. Applications of image coding algorithms in image compression standards and their use in selected fields such as medical imaging are discussed. At the end of the course the students are able to assess existing coding methods for still images and video. They know relevant problems of image acquisition and representation, how the information content in images can be estimated and learn principles in the design of encoders for image and video compression. Students are able to apply image coding methods in medical applications. **Content:** ▪ Acquisition and representation of images ▪ Human perception ▪ Image forming systems ▪ Information theory ▪ Quantisation ▪ Data compression ▪ Lossy coding ▪ Video compression ▪ Transform coding ▪ Content based and semantic coding ▪ Standards and applications
Literature	Many literature on image and video compression is helpful but doesn't replace necessity of being present at classes, e. g. John W. Woods: Multidimensional signal, image, and video processing and coding, Academic Press, 2012, (Online available), material for lecture and exercise is provided by e-learning system
Teaching	Lecture, Tutorial
Prerequisites	Modules typical for Bachelor in Electrical Engineering or related courses
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

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Responsible person	Dr.-Ing. Gerald Krell (FEIT-IIKT)

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Image Guided Procedures

Teaching	Seminar
Prerequisites	None
Applicability of the module	Master program
Examination	Written examination 60min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Seminar
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Michael Friebe (FEIT-IMT)

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Sub-Module: Medical Imaging in Interventional Endovascular Therapy

Objectives and content	**Objectives:** The students will: ▪ gain knowledge of basic interventional procedures ▪ understand the techniques of interventional treatment ▪ have an overview about imaging tasks and modalities for interventions ▪ learn about issues related to interventional treatment **Content:** The course is meant to provide a basic knowledge of the medical imaging techniques that are used in the endovascular interventional therapy of the vessel disease. The pathological conditions and the characteristics of the image guided therapy applied to treat the diseases will be also briefly elaborated. The course is consist of the following teaching blocks: ▪ Vascular disease ▪ Interventional ▪ Interventional imaging vs vascular surgery ▪ Interventional suite ▪ Preinterventional scanning in acute patients ▪ Interventional X-ray based 2D and 3D techniques ▪ Endovascular therapy of intracranial ▪ Endovacular therapy of AVM's ▪ Endovascular therapy of intracranial tumors ▪ Endovascular therapy of spine disease ▪ Functional imaging ▪ Post-interventional check up ▪ New technical developments in endovascular interventional imaging ▪ Pre-interventional virtual therapy planning ▪ New endovascular therapies on the horizon

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Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 1 SWS Seminar Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Dr. Drazenko Babic (Philips)

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Sub-Module: Seminar IGP

Objectives and content	**Objectives:** The students will learn the basics of medical applications in minimally invasive image guided surgeries / therapies and related hybrid imaging. They gain the knowledge to understand the complex medical environment as well as its challenges in order to improve these procedures (including logistics and imaging in the operating theatre of the future). With knowledge about technology they can model and master complex solutions. Besides the medical and technical knowledge, definition of clinical, technical projects in the field of intra operative imaging and navigation for minimal invasive surgery is the core focus during the course. Exposure to real world problems makes this a unique setup for modeling and implementing creative solutions. **Content:** ▪ Basics of some intraoperative and minimal-invasive surgeries ▪ Participation in an actual surgery and recording of the procedure - from patient anaesthesia to finish ▪ Dialogue with the surgeons about the procedure and highlighting the defined process including interfaces, logistical approaches, use of technologies ▪ Team-work analyzing these processes to identify possible improvements ▪ Translation into an actual improvement proposal for the surgical team ▪ Presentation to everyone on the procedure and the findings ▪ Final presentation including a proposal for the surgical teams - proposal can be a prototype, or a presentation, or a video, or . . .

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Literature	[1] Terry Peters and Kevin Cleary – Image Guided Interventions – Technology and Application [2] A. Wolbarst and W. Hendee, Evolving and experimental technologies in medical imaging, Radiology, 238 (2006), pp. 16-39 [3] Joerg Traub, New Concepts for Design and Workflow Driven Evaluation of Computer Assisted Surgery Solutions, 2008, TUM, Munich, Germany [4] Selected Workshop and Proceedings of the following congresses: IPCAI/CARS, MICCAI, SMIT [5] Lecture Script provided
Teaching	Seminar
Prerequisite for the admission to any examination	Seminar certificate
Work load	Time of attendance: 2 SWS Seminar Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Michael Friebe (FEIT-IMT)

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Instruments for IGP

Objectives and content	**Objectives:** The student will: ▪ Get an introduction (clinical and technical) to the actual use, potential and current limitations of IG procedures - main focus is on oncology, neuro-radiology, interventional radiology, head/neck and urology using XR, CT, MRI, US and ENDOSCOPY plus hybrid systems ▪ Learn the functionality and limitations of the main imaging systems used for IGP. ▪ Understand the use, function and limitations of the therapy tools (e. g. stents, implants, coils, flow diverter, pharmaceuticals, and accessory systems (e. g. RFA, laser, cryotherapy, endoscopy equipment, robots and manipulation units, navigation and tracking, monitoring and anaesthesia, dedicated software,. . .) used in IGP. ▪ Intraoperative versus minimal invasive versus intraoperative versus image guided. ▪ Get an understanding of the problems associated with IGP, particularly with respect to size, steerability, movability, sterility, visualization, therapy response, clinical quality assurance, forensic informations. ▪ Understand the material properties and the development needs for future tools and systems. **Content:** ▪ Present and evaluate example IGP procedures from the clinical fields ▪ Overview of diagnostic systems used for IGP (XR based, MRI, Ultrasound, Optical, Nuclear, hybrid, and others) with a focus on their key technical parameters and their current and potential use in IGP ▪ Therapy tools including material properties (Radiation therapy with nuklides / XR / . . . ; cryo- and laserprocedures, hyperthermia, catheter procedures, biopsies needle applications, vascular implants,. . . ▪ Accessory tools and systems for IGP. ▪ What is important (imaging and therapy) with respect to material, material mix, properties, artefacts, visualisation, guidance, tracking,. . . ? ▪ Outlook and potential of IGP - What are clinicians and scientists working on? ▪ Some hand-on experience using Ultrasound, XR, Endoscopy, and MRI ▪ What could (should) the future look like? Create a concept considering and applying the lecture content.
Literature	[1] T. M. Peters, "Image-guidance for surgical procedures", Physics in Medicine and Biology, vol. 51, no. 14, pp. R505?R540, Jul. 2006 [2] Ziv Yaniv and Kevin Cleary, "Image-Guided Procedures: A Review", Georgetown University, CAIMR TR-2006-3, Apr. 2006 [3] T. Peters and K. Cleary, Image-Guided Interventions: Technology and Applications, Auflage: 2008. New York: Springer, 2008 [4] F. L. Greene and B. T. Heniford, Minimally Invasive Cancer Management, 2nd ed. 2010. New York: Springer, 2010
Teaching	Lecture, Seminar
Prerequisites	None

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Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Written examination 60min
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:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Michael Friebe (FEIT-IMT)

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Lab course Electrophysiology

Objectives and content	**Objectives:** The student will: ▪ understand the medical background of electrophysiological signals ▪ learn how to measure electric biosignals ▪ have an overview about different modalities for bioelectric signals ▪ able to postprocess and filter signals from the human body ▪ apply theoretical signal processing knowledge to the medical field **Content:** ▪ Different types of bioelectric signals (EMG, ECG, EEG...) ▪ Medical background and origin of the derived signals ▪ Hardware for the measurement of bioelectrical signal ▪ Precise measurement of bioelectric signals ▪ Post processing of bioelectric signals ▪ Filtering of electric bio signals ▪ Analysis of bioelectric signal
Literature	
Teaching	Lab Project
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 Lab Project Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Georg Rose (FEIT-IMT)

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Machine Learning for Medical Systems

Objectives and content	**Objectives:** The student will ▪ understand the basics of Learning Theory ▪ get an in-depth understanding for problems and concepts in the area of Machine Learning ▪ learn data structures and algorithms of Machine Learning ▪ be enabled to apply these methods to real-world medical data analysis problems **Content:** ▪ Concept Learning and Version Space ▪ Learning Decision Trees ▪ Neural Networks ▪ Bayesian Learning ▪ Instance-based Learning and Cluster Analysis ▪ Association Rule Learning ▪ Reinforcement Learning ▪ Hypothesis Evaluation
Literature	
Teaching	Lecture, Seminar
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial 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:
Frequency	Every winter semester
Duration	One semester
Responsible person	Jun.-Prof. Dr.-Ing. Andreas Nürnberger (FIN-IWS)

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Master Thesis

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

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Mathematical foundations

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

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Medical Imaging and Diagnostics

Teaching	Lecture, Tutorial
Prerequisites	Mathematics, Physics, Fundamentals in Electrical Engineering, Basic understanding of medical terms
Applicability of the module	Master program
Examination	Written examination 90min
Credit Points	5 CP = 150 h (56 h time of attendance + 94 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture, 1 SWS Tutorial
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

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Sub-Module: Introduction into Medical Imaging

Objectives and content	**Objectives:** The student will: ▪ get on overview about modern medical imaging modalities ▪ understand the functional principle of the different technologies ▪ get to know to the most important medical applications of imaging ▪ discuss the pros and cons of the particular modalities with respect to image quality and patient safety ▪ have an overview about the required data and image processing **Content:** ▪ Radiography ▪ Computed Tomography ▪ Nuclear medicine imaging (PET, SPECT) ▪ Sonography ▪ Magnetic Resonance Imaging
Literature	
Teaching	Lecture, Tutorial
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

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Sub-Module: Radiological Diagnostics

Objectives and content	**Objectives:** ▪ Knowledge on the fundamental functions of common medical imaging methods from a medical point of view ▪ Knowledge of the characteristics of human tissues and their visualisation by imaging techniques ▪ Knowledge on the specufic problems of different techniques ▪ Understanding for the role of different techniques ▪ Knowledge on the demand for future medicine **Content:** The functioning of commonly used medical imaging techniques from a medical doctor´s point of view are addressed and related to specific characteristics of human tissues (X-ray density, relaxivity, water content. . .). Thus, the different imaging of diverse tissues by the respective imaging techniques are explained. The limitations odf the different methodological approaches are demonstrated. Demands for future medical imaging techniques with respect to still unanswered medical issues are addressed.
Literature	
Teaching	Lecture
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 1 SWS Lecture Autonomous work: Preparation of the Lectures and Tutorials, Learning of the respective structures and functions
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Martin Skalej (FME-ZRAD-INR)

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Medical Measurement Technology

Teaching	Lecture
Prerequisites	None
Applicability of the module	Compulsory module for the Master "Medical Systems Engineering"
Examination	Oral examination
Credit Points	6 CP = 180 h (56 h time of attendance + 124 h autonomous work)
Work load	Time of attendance in summer semester: 2 SWS Lecture Time of attendance in winter semester: 2 SWS Lecture
Frequency	Starts every summer semester
Duration	Two semesters
Responsible person	apl. Prof. Dr. rer. nat. habil. Ralf Lucklum (FEIT-IMOS)

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Sub-Module: Chemical and Biological Sensors

Objectives and content	**Objectives:** The students gain knowledge in fundamentals of chemical and biological sensors and their application in medicine. After finishing the module they will understand modern principles of chemical and biochemical sensors, including signal sources, signal propagation and detection. The students will be able applying chemical and biochemical sensors in hospital practice, point-of-care medicine, ambient assisted living and interdisciplinary science. They will further achieve basic knowledge in the design of sensors and sensor systems. **Content:** 1. Basics of chemical sensor and systematization 2. Thermodynamics, kinetics, sensitivity and selectivity 3. Electrochemical sensors and ISFETs 4. Catalytic principles 5. Resonant, MEMS, NEMS, MOMS sensors 6. Selected sensor systems applications
Literature	Watson, J., Chemical Sensors 1-6, Momentum Press 2010.
Teaching	Lecture
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 2 SWS Lecture Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every summer semester

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Duration	One semester
Responsible person	apl. Prof. Dr. rer. nat. habil. Ralf Lucklum (FEIT-IMOS)

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Sub-Module: Ultrasonic Sensors for Imaging

Objectives and content	**Objectives:** The students gain information on the fundamental concepts and principles of ultrasonic sensors and the characteristics and requirements of ultrasonic sensors for imaging. At the end of the module they are able to engineer ultrasonic sensors and apply the physics behind signal analysis for ultrasonic imaging. They will be able to join interdisciplinary groups working on ultrasonic imaging, develop new sensors and imaging schemes. **Content:** 1. Principles of generation and detection of ultrasound 2. Fundamentals of acoustic wave propagation 3. Methods of signal optimization and signal extraction 4. New trends in ultrasonic sensor development and imaging principles
Literature	[1] Sanches, J.M., Ultrasound Imaging: Advances and Applications, Springer 2012 dx.doi.org/10.1007/978-1-4614-1180-2. [2] Scabo, T.L., Diagnostic Ultrasound Imaging, Elsevier, 2007.
Teaching	Lecture
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 2 SWS Lecture Autonomous work: Post processing of lectures, preparation of exam
Frequency	Every winter semester
Duration	One semester
Responsible person	apl. Prof. Dr. rer. nat. habil. Ralf Lucklum (FEIT-IMOS)

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Medical Physics and Radiation Protection

Objectives and content	**Objectives:** The students will learn about the fundamentals of physics used in medicine or describing human biology. The main focus will be on the effects of ionising radiation on a human being and the consequences regarding the medical applications of ionising radiation since this is still the most important part of medical physics. This will include radiobiology, basic aspects of ionising radiation, radiation protection for various groups of people (patient, staff, public) radiation protection measures, methods of radiation therapy. Medical Imaging is described within the module introduction to medical imaging and will in this course only briefly be touched. In addition, the use of lasers will be discussed as well as audiology and some aspects of the human visual system. **Content:** ▪ Introduction - what is medical physics? ▪ Ionising radiation ▪ Radiation protection ▪ Radiation therapy ▪ Lasers in medicine ▪ Audiology ▪ Prospects
Literature	Wieland A. Worthoff Hans G. Krojanski Dieter Sute: Medical Physics - Exercises and Examples, de Gruyter, 2013
Teaching	Lecture
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Written examination 90min ⚠examination without additional help except a calculator
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture Autonomous work: recapture lectures, prepare tutorial, prepare exam, prepare short presentation
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Christoph Hoeschen (FEIT-IMT)

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Medical Visualization

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

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MedTec Innovation Generation and Entrepreneurship

Objectives and content	**Objectives:** The objective of this course is to teach students being an innovator in his employed function, as potential entrepreneur and to understand the innovation generation in the healthcare domain leading to sustaining / disruptive new products and services and could be a starting point for entrepreneurial activities. Students will learn a selection of proven design, motivation, and management methods for innovation creation of products / services / concepts for the Healthcare sector (including MedTec, Life Sciences, Medicine). **Content:** ▪ Business and market basics in biomedical / medical technology and related areas (software, services, products) ▪ Qualifications of a technology entrepreneur and a related high-tech venture (products and services) ▪ Introduction in setting up a startup company ▪ Presentation of innovation games, DESIGN THINKING, BLUE OCEAN, SWOT, and CANVAS (including the Value Proposition Canvas - VPC) for translation/improvement of ideas/concepts — dedicated for the MedTec segment ▪ Conceptual Blockbusting Techniques ▪ Basics of intellectual property rights (IP), marketing, sales, finances and how to finance a venture, team and staff issues, and other important knowledge blocks around high-tech entrepreneurship ▪ Develop a VPC around a chosen or a lecturer provided topic, verify the medical needs and Pain/Gains and change if needed (teamwork) ▪ Develop a road-map and a communication document for the planned innovation (teamwork) ▪ Present the concept and findings in front of a panel (teamwork)
Literature	[1] Yock, Zenios, Makower - Biodesign [2] Brant Cooper, Patrick Vlaskovits - The Lean Entrepreneur [3] Alexander Osterwalder - Value Proposition Design [4] Eric Ries - The Lean Startup
Teaching	Lecture, Seminar
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Seminar certificate
Examination	Written examination 60min
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:
Frequency	Every summer semester

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Duration	One semester
Responsible person	Prof. Dr.-Ing. Michael Friebe (FEIT-IMT)

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MEMS-Packaging for Medical Solutions

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

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Methods of MRI

Objectives and content	**Objectives:** ▪ Understanding of magnetic resonance principle ▪ Knowledge of spatial encoding in MR ▪ Knowledge of different MR measurement methods ▪ Understanding of MR reconstruction principles ▪ Understanding of physical and technical possibilities and limitations ▪ Ability to apply knowledge for simple modifications of MR sequences **Content:** ▪ MR signal generation ▪ MR signal evolution (Bloch equation) ▪ MR measurement parameters ▪ Spatial encoding ▪ MR measurement methods (sequences) ▪ MR reconstruction
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering, physics or related subjects, Basics of physics, mathematics and imaging systems
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: 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)

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Microsystems- and Nano-Technologies for Medical Solutions

Objectives and content	**Objectives:** The students gain knowledge in fundamentals of microsystems technologies as well as knowledge about medical products by means of MEMS and Nano technologies and future trends. After finishing the module they will understand the production technologies for MEMS- and Nano-devices and will be able applying these technologies for the conceptual development of miniaturized medical components (e.g. micropumps, microvalves, pressure sensors). They will further achieve basic knowledge about the requirements of medical MEMS products like sensors, actuators and microsystems. By means of exercises they learn to deepen their knowledge for further research and to apply it to solve complex problems. **Content:** ▪ MEMS and Nano: definition, technologies, markets ▪ Materials for MEMS and Nanotechnologies ▪ Cleanroom and vacuum techniques ▪ Thin film technologies: PVD, CVD ▪ Lithography: resists, optical lithography, e-beam and x-ray lithography ▪ Etching ▪ Bulk-micromachining, surface-micromachining, LIGA principles, ▪ Selected examples of medical micro- and nanosystems
Literature	Fundamentals of microfabrication: the science of miniaturization; Marc J. Madou. - 2. ed. - Boca Raton: CRC Press, 2002, ISBN: 0-8493-0826-7
Teaching	Lecture, Tutorial
Prerequisites	Bachelor in Electrical Engineering or related studies
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 120min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: Post processing of lectures, preparation of exercises, preparation of exam
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. rer. nat. Bertram Schmidt (FEIT-IMOS)

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Nuclear medicine

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

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Research Project

Objectives and content	**Objectives:** ▪ Learn to handle and solve a scientific project with the guidance of a supervisor ▪ Learn to acquire expertise and the identification of interdependencies within a scientific problem ▪ Obtain the qualification for autonomous research work ▪ Get an expert in the writing of a scientific report ▪ Practice speaking skills by the presentation of the final results and preliminary work **Content:** Up-to-date research problem defined together with the supervisor
Literature	
Teaching	None
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	Proposal
Examination	Research project
Credit Points	20 CP = 600 h (0 h time of attendance + 600 h autonomous work)
Work load	Time of attendance in winter semester: Individual decision Time of attendance in summer semester: Individual decision Autonomous work:
Frequency	Starts every winter semester
Duration	Two semesters
Responsible person	project supervisor

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Rheology and Rheometry

Objectives and content	**Objectives:** The majority of fluid substances surrounding us have non-Newtonian properties (pharmaceutical and medical equipment, cosmetics, food processing, petrochemical, building materials industry, ceramic industry, paint industry, polymer production...). The flow behavior of these substances plays a central role in the production and application engineering, quality assurance, materials research and development. Starting with rheological phenomena, the physical properties such as viscosity, elasticity and plasticity are discussed. This is followed by a classification, and the mathematical description of the rheological equations of the media. Simple rheological laminar flows are treated, before turbulent properties are discussed. Current measurement methods and derived models are in the focus of the course. After participating in this module, the students master all the basic concepts that are necessary for the description of complex fluids. They know the characteristics of non-Newtonian fluids, as well as their economic importance and the most important areas of applications. They are able to identify complex material behavior, characterize, interpret and incorporate into theoretical / numerical models. Students are also guided through practical exercises in order to carry out tests with rheometers and to interpret results. **Content:** ▪ Basics of rheology, subdivisions, rheological phenomena (concepts and definitions, behavior due to stress, elastic and viscous media) ▪ Physical principles, conservation laws ▪ Simple forms of deformation ▪ Rheological measurement principles, tools and methods (stationary methods, transient methods, type of rheometers, measurement of other rheological parameters) ▪ Classification: ideal body: Newton, Hooke, St. Venant body; non-Newtonian viscous liquids: viscoelastic liquids. ▪ Methods of establishing the flow curve (approximation of the yield curve, semi-theoretical approaches, molecular kinetic approaches, mechanical models) ▪ Effect of temperature, pressure, composition ▪ Technical engineering applications (gap flow, pipe flow, annular gap flow, slot die, agitator, extruder design) ▪ Rheology of biological and biomedical fluids
Literature	C. Macosko, "Rheology", VCH Wiley Publishers
Teaching	Lecture, Research Project
Prerequisites	Fluid mechanics, Thermodynamics, Mechanics
Applicability of the module	Master program

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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 Research Project Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Dominique Thévenin (FVST-ISUT)

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Scientific working

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

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Selected Topics in Image Understanding

Objectives and content	**Objectives:** ▪ Algorithmic solution of advanced Digital Image Analysis topics ▪ Project execution in a scientific-analytical environment ▪ Communication of scientific contents in English **Content:** ▪ Advanced segmentation techniques ▪ Feature generation, feature mapping and feature reduction ▪ Geometric a priori models for image understanding ▪ Classification techniques
Literature	
Teaching	Lecture, Tutorial
Prerequisites	Basic Computer Science and programming skills, basic knowledge in image processing
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: ▪ Project preparation and performance in small work groups ▪ Preparation of a project presentation ▪ Preparation and postprocessing of the subject matter
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Klaus Tönnies (FIN-ISG)

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Simulation and Numerical Methods in Biomechanics and Medical Engineering

Teaching	Lecture, Seminar, Tutorial
Prerequisites	Basics in engineering mechanics
Applicability of the module	Master program
Examination	Thesis, Oral examination
Credit Points	10 CP = 300 h (70 h time of attendance + 230 h autonomous work)
Work load	Time of attendance in winter semester: 3 SWS Lecture, 1 SWS Tutorial Time of attendance in summer semester: 1 SWS Seminar
Frequency	Starts every winter semester
Duration	Two semesters
Responsible person	Juhre

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Sub-Module: Computational Biomechanics

Objectives and content	**Objectives:**
	The lecture is aimed to provide the students with knowledge and skills in computational mechanics to solve engineering problems (statics, strength of materials, dynamics). The lecture provides an introduction into the mathematical modeling and the computational analysis of engineering problems. The students receive the ability to solve simplified technical problems with a reference to biomechanical and medical engineering.
	Content:
	▪ Overview about modern computational methods in mechanics
	▪ and there application in biomechanics and medical engineering
	▪ Introduction in mathematical modeling
	▪ Discretization methods:
	  ▫ Finite difference method (FDM)
	  ▫ Energy Methods (Ritz, Galerkin)
	  ▫ Finite element method (FEM)
	  ▫ Multi body dynamics (MBS)
	▪ Computational analysis of selected problems in biomechanics

Literature	
Teaching	Lecture, Tutorial
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 3 SWS Lecture, 1 SWS Tutorial Autonomous work: re-working of lectures, autonomous execution of exercises, preparation of the exam

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Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. habil. Dr. h. c. Ulrich Gabbert (FMB-IFME)

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Sub-Module: Simulation in Medicine and Medical Engineering

Objectives and content	**Objectives:** ▪ This course is intended to teach students about simulation methods and systems in medical and medical engineering applications. ▪ Taking methods for the generation and representation of medical models (organs, patients and instruments) as the starting point, methods for the real-time simulation of surgical procedures shall be treated. ▪ Fundamental principles of methods of immersive visualization (virtual and augmented reality) shall be taught in the context of medical applications. ▪ Independent study of topics shall teach students practical skills to solve specific problems in the field of simulation. **Content:** ▪ Presentation of selected medical engineering systems (e. g. minimally invasive diagnostic and therapy systems) ▪ Model representations and overview of methods of modeling ▪ Methods of real-time simulation and visualization of properties of biological objects/organs for training simulations (interaction, collision detection, deformation modeling, topological modifications, visual effects, camera simulation) ▪ Haptic systems in medical simulation environments (systems overview, parameters, connection to a simulation) ▪ Methods of immersive visualization (types of stereoscopic representation, augmented reality 3-D model overlay, tracking methods, camera equipment, camera calibration) ▪ Presentation of current research studies on the use of virtual and augmented reality in medicine/medical engineering ▪ Independent practical study (autonomous work): Assignment of topics related to simulation, visualization and tracking for medical engineering applications (academic research and programming)
Literature	
Teaching	Seminar
Prerequisite for the admission to any examination	None
Work load	Time of attendance: 1 SWS Seminar Autonomous work: independent practical study
Frequency	Every summer semester

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Duration	One semester
Responsible person	Dr.-Ing. Rüdiger Mecke (Fraunhofer-Institut IFF, MD)

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Theoretical Neuroscience I

Objectives and content	**Objectives:** **Content:** Based on Chapters 5-6 and Chapters 1-4 of Dayan & Abbott. Electrochemical equilibrium and Nernst Equation, equivalent circuits for single-compartment model, leaky integrate-and-fire model, Hodgkin-Huxley and Connor-Stevens models of action potential, cable equation and neuron morphology, characterizing neuronal responses with tuning curves and receptive fields, signal-detection theory and psychometric function, comparision of neuronal and behavioural responses with neurometric function, population coding, statistically efficient decoding with maximum likelihood and maximum a posteriori likelihood, Fisher information, introduction to Shannon information, application of Shannon information to neural responses. To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam. The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Sterrat, Graham, et al., "Principles of Computational Modelling in Neuroscience", 2011
Teaching	Lecture
Prerequisites	First degree in physics, mathematics, or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010.
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 180min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture Autonomous work:
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr. Jochen Braun (FNW-IBIO)

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Theoretical Neuroscience II

Objectives and content	**Objectives:** **Content:** Based on Chapters 7-10 of Dayan & Abbott. Rate models of network dynamics, synaptic plasticity, reinforcement learning, and generative models. Linear models of neural networks, dynamic analysis of state-space, eigenvalue analysis of steady-states, models of activity-dependent plasticity, associative learning with neural networks, modern theories of reinforcement learning (Rescorla-Wagner, temporal-difference, actor-critic models), and abstract approaches to representational learning and generative models (expectation maximization, principal components, independent components). To develop a deeper understanding and to acquire applied and practical skills, students perform weekly homework assignments with Matlab programming. A passing grade on all assignments is required for admission to the final exam. The tutorial is open to all students and provides an opportunity for more extensive questions and discussions of the lecture material. It is particularly recommended for students with a weaker background in mathematics and physics.
Literature	[1] Dayan & Abbott, "Theoretical Neuroscience", 2001 [2] Wilson, "Spikes, Decisions, Actions: the Dynamical Foundations of Neuroscience", OUP 1999 [3] Sutton & Barto, "Reinforcement Learning: an Introduction", MIT Press, 1999
Teaching	Lecture
Prerequisites	First degree in physics, mathematics, or engineering, or self-study of Gabbiani & Cox, "Mathematics for Neuroscientists", 2010.
Applicability of the module	Master program
Prerequisite for the admission to any examination	Tutorial certificate
Examination	Written examination 180min
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 3 SWS Lecture Autonomous work:
Frequency	Every summer semester
Duration	One semester
Responsible person	Prof. Dr. Jochen Braun (FNW-IBIO)

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Tomographic Imaging in Medicine

Objectives and content	**Objectives:** The student will ▪ understand the theoretical and experimental fundamentals of Tomographic Imaging ▪ have an overview on relevant medical tomographic techniques ▪ gain knowledge about the technical parameters that control the quality of medical images ▪ get acquainted with selected software packages used for the graphical representation of medical images **Content:** ▪ Introduction ▪ Theoretical and practical fundamentals of tomographic imaging ▪ Measurement sensitivity and dynamic range ▪ Acoustic Tomography ▪ Magnetic-Spin-Resonance Tomography ▪ Microwave Imaging ▪ Ultra-Wide-Band Imaging ▪ Selected software package for graphical representation of medical images
Literature	
Teaching	Lecture, Tutorial
Prerequisites	None
Applicability of the module	Master program
Prerequisite for the admission to any examination	None
Examination	Oral examination
Credit Points	5 CP = 150 h (42 h time of attendance + 108 h autonomous work)
Work load	Time of attendance: 2 SWS Lecture, 1 SWS Tutorial Autonomous work: post processing of lectures, preparation of exercises, research report and exam
Frequency	Every winter semester
Duration	One semester
Responsible person	Prof. Dr.-Ing. Abbas Sayed Omar (FEIT-IIKT)

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