M.Sc. Biomedical Engineering (PO 2021)

Module manual
Date: 01.09.2021

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: M.Sc. Biomedical Engineering (PO 2021)

Date: 01.09.2021

Department of Electrical Engineering and Information Technology
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Contents

1 Fundamentals of Biomedical Engineering

Notes on this module manual:

(1) These module manuals are automatically generated from TUCaN. For modules that do not come from the Department of Electrical Engineering and Information Technology, it is unfortunately not possible to map any concrete offer semesters (winter or summer semesters).

(2) The General Examination Regulations of TU Darmstadt and the definitions laid down therein apply.

(3) Modules whose module number begins with "18-mt-xxxx" are offered by the Johann Wolfgang Goethe University Frankfurt am Main.

Module name Medical Device Regulation					
Module Nr. 18-mt-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1	**Content** • Introduction • Quality management system according to ISO 13485 • Processes according to the quality management system • Verification and Validation • Requirements of the MDR • Classification and placing medical products on the market • Risk Management • Clinical evaluation and investigation • Post-market surveillance • The system of notified bodies • Audits
2	**Learning objectives / Learning Outcomes** Students receive a broad and practical overview of medical device regulation. After attending this module students are able to work according to legal and regulatory requirements and to contribute to the approval of medical devices.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*

7	**Grade bonus compliant to §25 (2)**			
8	**References** • 2017/745/EU Medical Device Regulation • ISO 13485: 2016 – Medical devices – Quality management systems – Requirement for Stand: 12.03.2020 Seite 2 regulatory purposes			
Courses				
	Course Nr. 18-mt-2010-vl	**Course name** Medical Device Regulation		
	Instructor Prof. Dr.-Ing. Jürgen Adamy		**Type** Lecture	**SWS** 2

2 Optional Technical Subjects

Module name Bioinformatics II					
Module Nr. 18-kp-2120	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1	**Content** • Elementary methods of machine learning: Regression, classification, clustering (probabilistic graphical models) • Analysis and visualization of high-dimensional data (multi-dimensional scaling, principal component analysis, embedding methods with deep neural networks, tSNE, UMAP) • Data-driven reconstruction of molecular interaktion networks (Bayes nets, solution to Gausian graphical models, Causality analysis) • Analysis of interaction networks (modularity, graph partitioning, spanning trees, differential networks, network motifs, STRING database, PathBLAST) • Dynamical models of molecular interaction networks (stochastic Markov-modes, differential equations, Reaction rate equation) • Elementary algorithms for structure determination of proteins and RNAs (Secondary structure prediction of RNAs, molecular dynamics, common simulators and force fields)
2	**Learning objectives / Learning Outcomes** After successful completion of this module, students will be familiar with current statistical methods for analyzing high-throughput data in molecular biology. They know how to analyze high-dimensional data by reduction, visualization and clustering and how to find dependencies in these data. They know methods for dynamic description of molecular interactions. They are aware of common methods for structure prediction of biomolecules. Upon completion, students will be able to independently implement the presented algorithms in programming languages, such as Python, R or Matlab. In the area of communicative competence, students have learned to exchange information, ideas, problems and solutions in the field of bioinformatics with experts and with laypersons.
3	**Recommended prerequisite for participation** Bioinformatics I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 11 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**

8	**References**			
Courses				
	Course Nr. 18-kp-2120-vl	**Course name** Bioinformatics II		
	Instructor Prof. Dr. techn. Heinz Köppl		**Type** Lecture	**SWS** 2

Module name Microwaves in Biomedical Applications					
Module Nr. 18-jk-2110	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Electromagnetic properties of technical and biological materials on the microscopic and macroscopic level, polarization mechanisms in dielectrics and their applications, interaction between electromagnetic waves and biological tissue; passive microwave circuits with lumped elements (RLC-circuits) and their graphical representation in a smith chart, impedance matching; theory and applications of transmission lines, scattering-matrix formulation of microwave networks (S-parameters) and their characterization based on s-parameters; microwave components for medical applications, biological effects of electromagnetic fields, microwave-based tissue characterization and mimicking of biological tissue dielectric properties (phantoms); heat transfer in tissue from electromagetic fields, microwave systems for diagnosis and therapy, e.g., radar-based vital signs monitoring and microwave ablation of cancer.
2	**Learning objectives / Learning Outcomes** Students are able to understand basic fundamentals of microwave engineering and their application for biomedical applications. The interaction between electromagnetic waves with dielectric and biological materials are known. The students master the mathematical basis of passvie RF-circuits and their graphical representaion in a smith chart. They are able to apply the transmission line theory to fundamental applications. They can characterize microwave networks in s-parameter representations. The functionality and application of RF-components for biomedicine are known. Students understand the biological effects of electromagnetic fields and are able to derive diagnostic and therapeutic applications.
3	**Recommended prerequisite for participation** Fundamentals of electrical engineering
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** The script is provided and a list with recommended literature is presented in the lecture.

Courses

Course Nr. 18-jk-2110-vl	**Course name** Microwaves in Biomedical Applications		
Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		**Type** Lecture	**SWS** 3
Course Nr. 18-jk-2110-ue	**Course name** Microwaves in Biomedical Applications		
Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		**Type** Practice	**SWS** 1

Module name					
Digital Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2060	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** 1) Discrete-Time Signals and Linear Systems – Sampling and Reconstruction of Analog Signals 2) Digital Filter Design – Filter Design Principles; Linear Phase Filters; Finite Impulse Response Filters; Infinite Impulse Response Filters; Implementations 3) Digital Spectral Analysis - Random Signals; Nonparametric Methods for Spectrum Estimation; Parametric Spectrum Estimation; Applications; 4) Kalman Filter
2	**Learning objectives / Learning Outcomes** Students will understand basic concepts of signal processing and analysis in time and frequency of deterministic and stochastic signals. They will have first experience with the standard software tool MATLAB.
3	**Recommended prerequisite for participation** Deterministic signals and systems theory
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, Wi-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Course manuscript Additional References: • A. Oppenheim, W. Schafer: Discrete-time Signal Processing, 2nd ed. • J.F. Böhme: Stochastische Signale, Teubner Studienbücher, 1998

Courses

Course Nr. 18-zo-2060-vl	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Martin Gölz		**Type** Lecture	**SWS** 3
Course Nr. 18-zo-2060-ue	**Course name** Digital Signal Processing		
Instructor Prof. Dr.-Ing. Abdelhak Zoubir, M.Sc. Martin Gölz		**Type** Practice	**SWS** 1

Module name Statistics for Economics					
Module Nr. 04-10-0593	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Frank Aurzada		

1	**Content** Descriptive statistics, probability calculus, random variables, distributions, limit theorems, point estimation, confidence intervals, hypothesis tests
2	**Learning objectives / Learning Outcomes** After the course the students are able to * describe the basics of descriptive and inductive statistics. * conduct the main operations of probability calculus. * apply statistical estimation and testing procedures correctly. * recognize the relevance of statistical analyses for business and economic problems. * judge the results of statistical analyses and to communicate them orally and in written form correctly
3	**Recommended prerequisite for participation** recommended: Mathematik I and II
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** Wirtschaftsingenieurwesen and Wirtschaftsinformatik (Bachelor)
7	**Grade bonus compliant to §25 (2)**
8	**References** Bamberg, G., Baur, F., Krapp, M.: Statistik Fahrmeir L. et al.: Statistik: Der Weg zur Datenanalyse Papula, L.: Mathematik für Ingenieure und Naturwissenschaftler, Band 3

Courses

	Course Nr. 04-10-0593-vu	**Course name** Statistics for Economics		
	Instructor		**Type** Lecture & Practice	**SWS** 3

Module name Microsystem Technology					
Module Nr. 18-bu-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1	**Content** Introduction and definitions to micro system technology; definitions, basic aspects of materials in micro system technology, basic principles of micro fabrication technologies, functional elements of microsystems, micro actuators, micro fluidic systems, micro sensors, integrated sensor-actuator systems, trends, economic aspects.
2	**Learning objectives / Learning Outcomes** To explain the structure, function and fabrication processes of microsystems, including micro sensors, micro actuators, micro fluidic and micro-optic components, to explain fundamentals of material properties, to calculate simple microsystems.
3	**Recommended prerequisite for participation** BSc
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Mikrosystemtechnik

Courses

Course Nr. 18-bu-2010-vl	**Course name** Microsystem Technology		
Instructor Prof. Ph.D. Thomas Peter Burg		**Type** Lecture	**SWS** 2
Course Nr. 18-bu-2010-ue	**Course name** Microsystem Technology		
Instructor Prof. Ph.D. Thomas Peter Burg		**Type** Practice	**SWS** 1

Module name Sensor Technique					
Module Nr. 18-kn-2120	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content**
2	**Learning objectives / Learning Outcomes** The Students acquire knowledge of the different measuring methods and their advantages and disadvantages. They can understand error in data sheets and descriptions interpret in relation to the application and are thus able to select a suitable sensor for applications in electronics and information, as well process technology and to apply them correctly.
3	**Recommended prerequisite for participation** Measuring Technique
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC, MSc Medizintechnik
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Script of lecture • Textbook Tränkler „Sensortechnik“, Springer • Exercise script

Courses

	Course Nr. 18-kn-2120-vl	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Lecture	**SWS** 2
	Course Nr. 18-kn-2120-ue	**Course name** Sensor Technique		
	Instructor Prof. Dr. Mario Kupnik		**Type** Practice	**SWS** 1

Module name Fundamentals and technology of radiation sources for medical applications					
Module Nr. 18-bf-2040	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Content** The course covers the following topics: • Types of radiation • Overview of radiation sources in medicine • Basics of particle acceleration • X-ray tubes • Particle accelerators and applications in medicine • Radionuclide production • Irradiation devices and facilities in medicine
2	**Learning objectives / Learning Outcomes** The students know the types of radiation relevant to medicine, their properties and their generation. The simple X-ray tube as an introductory example is understood in its function. The basic principles of modern particle accelerators for direct or indirect irradiation are understood and the different types of accelerators for medicine can be distinguished. The generation processes of radionuclides and their application in facilities for irradiation are understood.
3	**Recommended prerequisite for participation** 18-kb-1040 Anwendung der Elektrodynamik
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 120 min, Standard Grading System) The examination is a written exam (duration: 120 min.). If it is foreseeable that fewer than 21 students will register, the examination will be oral (duration: 45 min.). The type of examination will be announced at the beginning of the course.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Medizintechnik*
7	**Grade bonus compliant to §25 (2)**
8	**References** • Strahlungsquellen für Technik und Medizin, Hanno Krieger, Springer (2014)

Courses

Course Nr.	**Course name**		
18-bf-2040-vl	Fundamentals and technology of radiation sources for medical applications		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Lecture	2
Course Nr.	**Course name**		
18-bf-2040-ue	Fundamentals and technology of radiation sources for medical applications		
Instructor		**Type**	**SWS**
Prof. Dr. Oliver Boine-Frankenheim		Practice	2

Module name					
System Dynamics and Automatic Control Systems II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-1010	7 CP	210 h	135 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1 Content

Main topics covered are:

- Root locus method (construction and application),
- State space representation of linear systems (representation, time solution, controllability, observability, observer- based controller design)

2 Learning objectives / Learning Outcomes

After attending the lecture, a student is capable of:

- constructing and evaluating the root locus of given systems
- describing the concept and importance of the state space for linear systems
- defining controllability and observability for linear systems and being able to test given systems with respect to these properties
- stating controller design methods using the state space, and applying them to given systems
- applying the method of linearization to non-linear systems with respect to a given operating point

3 Recommended prerequisite for participation

System Dynamics and Control Systems I

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

BSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Systemdynamik und Regelungstechnik II, Shaker Verlag (available for purchase at the FG office)

Courses

Course Nr.	Course name		
18-ad-1010-vl	System Dynamics and Automatic Control Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Lecture	3
Course Nr.	**Course name**		
18-ad-1010-ue	System Dynamics and Automatic Control Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Practice	2

Module name Visual Computing					
Module Nr. 20-00-0014	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1	**Content** - Basics of perception - Basic Fourier transformation - Images, filtering, compression & processing - Basic object recognition - Geometric transformations - Basic 3D reconstruction - Surface and scene representations - Rendering algorithms - Color: Perception, spaces & models - Basic visualization
2	**Learning objectives / Learning Outcomes** After successful participation in the course students are able to describe the foundational concepts as well as the basic models and methods of visual computing. They explain important approaches for image synthesis (computer graphics & visualization) and analysis (computer vision) and can solve basic image synthesis and analysis tasks.
3	**Recommended prerequisite for participation** Recommended: Participation of lecture “Mathematik I/II/III”.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0014-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0014-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik B.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik B.Sc. Computational Engineering B.Sc. Informationssystemtechnik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Literature recommendations will be updated regularly, an example might be: - R. Szeliski, “Computer Vision: Algorithms and Applications”, Springer 2011 - B. Blundell, “An Introduction to Computer Graphics and Creative 3D Environments”, Springer 2008
Courses	

	Course Nr. 20-00-0014-iv	Course name Visual Computing		
	Instructor		Type Integrated Course	SWS 3

3 Optional Subjects Medicine

3.1 Optional Subjects Medical Imaging and Image Processing

Module name Clinical requirements for medical imaging					
Module Nr. 18-mt-2020	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Thomas Vogl		
1	**Content** The module deals with the requirements for imaging methods in clinical diagnostics. Basic knowledge of the anatomy and clinic of common clinical pictures in internal medicine and surgery is discussed. On this basis, possible areas of application of imaging methods for diagnosis are discussed. In addition, the necessity and goals of the respective diagnostics for the clinical referrer are explained. In this context, the different meaningfulness of individual procedures is dealt with. Another perspective of the module is the explanation of typical problems of imaging diagnostics in the course of clinical routine such as structural, patient-related and particularly technical requirements or restrictions. The participants are given the path from the choice of imaging diagnostics to their assessment using common image examples (some of which are case-oriented).				
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students understand the requirements for imaging methods in clinical diagnostics. They know the common indications for imaging diagnostics in the context of common clinical pictures, especially from the fields of surgery and internal medicine. Based on basic anatomical-pathophysiological knowledge, they understand the goal of the requested diagnosis. They also know about differences in imaging methods in terms of sensitivity, specificity, invasiveness, radiation exposure and cost-benefit ratio. Typical structural, technical and patient-related problems in everyday routine diagnostics are known.				
3	**Recommended prerequisite for participation**				
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 60 min, Standard Grading System)				
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)				
6	**Usability of this module** *M.Sc. Biomedical Engineering*				
7	**Grade bonus compliant to §25 (2)**				
8	**References** Will be announced at the event				
Courses					

	Course Nr.	Course name		
	18-mt-2020-vl	Clinical requirements for medical imaging		
	Instructor		**Type**	**SWS**
	Prof. Dr. Thomas Vogl		Lecture	2

Module name Human vs. Computer in diagnostic imaging					
Module Nr. 18-mt-2030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Content** The module deals with imaging diagnostics in routine clinical practice. For this purpose, students are taught common areas of application of imaging techniques. In addition, the goals and value for the treating doctor are explained to them. In this context, common clinical pictures are used as examples to discuss the general, case-oriented benefits, risks and costs of the respective procedures. The participants will also be given an explanation of image analysis and image diagnosis, especially with regard to the medical question. Previous and newer technical aids are discussed. This includes filters, processing tools and evaluation algorithms. In addition, frequent human and technical sources of error as well as weaknesses in imaging diagnostics are discussed. Advantages, disadvantages and limitations of computer-assisted image analysis are explained using typical everyday examples. Differences between humans and computers in image assessment such as the integration of clinical information are explained.
2	**Learning objectives / Learning Outcomes** The students know the areas of application of imaging methods in clinical routine. They understand the goal and the value of the requested diagnostics. They can also assess requirements for the chosen method and the limitations of this method. They are familiar with various technical aids such as image processing tools and evaluation algorithms and can continue to assess their advantages and disadvantages. They also know about the differences between human and purely computer-assisted image analysis and image assessment. Common sources of error and their causes are known. After successfully completing the module, the students can explain the advantages and limitations of human and computer-assisted image assessment and understand their differential diagnostic potential. They are familiar with the latest technical aids that have been used to date. In addition, they can assess the methodological significance of frequent medical questions.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced at the event

Courses

Course Nr.	**Course name**		
18-mt-2030-vl	Human vs. Computer in diagnostic imaging		
Instructor Prof. Dr. Thomas Vogl		**Type** Lecture	**SWS** 2

3.2 Optional Subjects Radiophysics and Radiation Technology in Medical Applications

Module name Radiotherapy I					
Module Nr. 18-mt-2040	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner**		

1	**Content** Basic aspects of radiation therapy; legal framework for the use of ionising radiation in medicine; range of applications of ionising radiation in therapy; systems and devices for percutaneous, intracavitary and interstitial therapy with ionising radiation; physical and technical aspects of systems and devices for the application of ionising radiation in therapy; clinical dosimetry of ionising radiation in therapy; quality assurance in radiation therapy.
2	**Learning objectives / Learning Outcomes** The students receive sound basic knowledge of the generation, application and quality assurance of ionising radiation for use in radiotherapy. They know the functioning of systems and devices for percutaneous, intracavitary and interstitial therapy with ionising radiation. They are familiar with the essential aspects of dosimetry and quality assurance of radiation therapy devices as well as the relevant medical requirements. They have knowledge of the specific issues of radiation protection in the use of ionising radiation in therapy.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Krieger: „Grundlagen der Strahlungsphysik und des Strahlenschutzes", 6. Auflage, Springer Spektrum, 2019 Krieger: „Strahlungsmessung und Dosimetrie", 2. Auflage, Springer Spektrum, 2013 Krieger: „Strahlungsquellen für Technik und Medizin", 3. Auflage., Springer Spektrum, 2018 Schlegel, Karger, Jäckel: „Medizinische Physik", Springer Spektrum, 2018 Wannenmacher, Wenz, Debus: „Strahlentherapie", Springer, 2013

Courses

Course Nr. 18-mt-2040-vl	**Course name** Radiotherapy I		
Instructor		**Type** Lecture	**SWS** 2

Module name Radiotherapy II					
Module Nr. 18-mt-2050	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner**		

1	**Content** Basic aspects of radiotherapy planning; basic medical and physical principles of therapy planning; imaging modalities in therapy planning; commissioning of radiation sources in tele- and brachytherapy; conventional and inverse radiation planning; algorithms for dose calculation: pencil beam, collapsed cone and Monte Carlo; quality assurance in radiation planning; special aspects of radiation planning in stereotactic or radiosurgical radiotherapy; special features of radiation planning in brachytherapy
2	**Learning objectives / Learning Outcomes** The students receive sound basic knowledge in radiation planning for percutaneous, intracavitary and interstitial therapy with ionising radiation; they know the basic medical and physical principles of therapy planning and are familiar with different planning procedures and algorithms. They are familiar with the procedures for quality assurance in radiation planning.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Krieger: „Grundlagen der Strahlungsphysik und des Strahlenschutzes", 6. Auflage, Springer Spektrum, 2019 Krieger: „Strahlungsmessung und Dosimetrie", 2. Auflage, Springer Spektrum, 2013 Krieger: „Strahlungsquellen für Technik und Medizin", 3. Auflage., Springer Spektrum, 2018 Schlegel, Karger, Jäckel: „Medizinische Physik", Springer Spektrum, 2018 Wannenmacher, Wenz, Debus: „Strahlentherapie", Springer, 2013

Courses

	Course Nr. 18-mt-2050-vl	**Course name** Radiotherapy II		
	Instructor		**Type** Lecture	**SWS** 2

Module name Nuclear Medicine					
Module Nr. 18-mt-2060	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner**		

1	**Content** Basic principles of nuclear medical diagnostics and therapy (radiopharmaceuticals); biological radiation effects and toxicity of radioactively labelled substances; biokinetics of radioactively labelled substances, determination of organ doses; radiation measurement technology and dosimetry in nuclear medicine; imaging: Planar gamma camera systems, emission tomography with gamma rays (SPECT), positron emission tomography (PET); data acquisition and processing in nuclear medicine; in vivo examination methods; in vitro diagnostics; nuclear medicine therapy and intratherapeutic dose measurement; quality control and quality assurance; radiation protection of patients and staff; planning and setting up nuclear medicine departments
2	**Learning objectives / Learning Outcomes** The students receive sound basic knowledge of nuclear medicine. They know the physical and biological properties of different radiopharmaceuticals and are familiar with the dosimetric procedures in nuclear medicine. They know the different systems and procedures of nuclear medical diagnostics and therapy. They have knowledge of the specific issues of radiation protection in the use of ionising radiation in nuclear medicine.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Krieger: „Grundlagen der Strahlungsphysik und des Strahlenschutzes", 6. Auflage, Springer Spektrum, 2019 Krieger: „Strahlungsmessung und Dosimetrie", 2. Auflage, Springer Spektrum, 2013 Krieger: „Strahlungsquellen für Technik und Medizin", 3. Auflage., Springer Spektrum, 2018 Schlegel, Karger, Jäckel: „Medizinische Physik", Springer Spektrum, 2018 Grünwald, Haberkorn, Kraus, Kuwert; „Nuklearmedizin", 4. Auflage, Thieme, 2007

Courses

Course Nr.	Course name		
18-mt-2060-vl	Nuclear Medicine		
Instructor		**Type** Lecture	**SWS** 2

3.3 Optional Subjects Digital Dentistry and Surgical Robotics and Navigation

Module name Digital Dentistry and Surgical Robotics and Navigation I					
Module Nr. 18-mt-2070	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The module deals with the basics methods and devices with which preoperative three-dimensional treatment planning can be carried out in the speciality areas of surgery and digital dentistry, and which also can be transferred to the intraoperative situation to support the practitioner. The procedures range from preoperative data acquisition (intra- and extraoral scanning systems, radiological procedures such as computed tomography, magnetic resonance imaging, cone-beam computed tomography) and the various software-based 3D-planning procedures by intraoperative passive (navigation, augmented reality) and active (robotics, Telemanipulation) systems. One focus is the application in the areas of neuronavigation, spine and pelvic surgery in trauma, hand and reconstructive surgery, oncologic surgery, especially in the field of urology, and various areas of reconstructive dentistry such as dental implantology, jaw reconstructions or care with individual dentures.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students have first insights into the principles, strategies and concepts of medical and dental robotics and navigation as well as the functionality of the associated software and devices. They will be able to describe the workflow from data acquisition to intraoperative implementation. They know the basic advantages and limitations of the various procedures in different medical and dental applications and can independently apply this knowledge to interdisciplinary issues in surgery and digital dentistry together with engineering and thus formulate basic specialist positions.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event.

Courses

Course Nr.	**Course name**		
18-mt-2070-vl	Digital Dentistry and Surgical Robotics and Navigation I		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Robert Sader		Lecture	2

Module name Digital Dentistry and Surgical Robotics and Navigation II					
Module Nr. 18-mt-2080	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The module deepens the learning content presented in Lecture I and comprehensively presents the methods and devices with which preoperative three-dimensional treatment planning in the fields of surgery and digital dentistry can be carried out and can also transferred to the intraoperative situation to support the practitioner. These medical technology processes, concepts and associated device technologies are now presented in the narrow context of their medical applications. One focus is the application in the areas of neuronavigation, spinal and pelvic surgery in trauma, hand and reconstructive surgery, oncologic surgery, especially in the field of urology, and various areas of reconstructive dentistry such as dental implantology, jaw reconstruction or the supply of individual dentures.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, students have comprehensive insights into the current principles, strategies and concepts of medical and dental robotics and navigation as well as the functionality of the associated software and devices. They are able to describe the workflow from data acquisition to intraoperative implementation and to understand the functionalities of the disciplines involved in their interdisciplinary networking as well as the related interface problems. They know the advantages and limitations of the various procedures in different medical and dental applications. In addition, they can independently apply the knowledge they have acquired to interdisciplinary issues in surgery and digital dentistry together with engineering and thus formulate subject-related positions.
3	**Recommended prerequisite for participation** Digital Dentistry and Surgical Robotics and Navigation I
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc Medical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event

Courses

Course Nr. 18-mt-2080-vl	**Course name** Digital Dentistry and Surgical Robotics and Navigation II	
Instructor Prof. Dr. Dr. Robert Sader	**Type** Lecture	**SWS** 2

Module name Digital Dentistry and Surgical Robotics and Navigation III					
Module Nr. 18-mt-2090	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The module deepens the learning content presented in Lecture I and presents the latest and visionary methods and devices with which preoperative three-dimensional treatment planning in the fields of surgery and digital dentistry can be carried out and transferred to the intraoperative situation to support the practitioner. These medical technology processes, concepts and associated device technologies are presented problem-oriented and in the narrow context of their medical applications. Based on existing technology problems, future developments in medical technology are presented and discussed. One focus is the application in the areas of neuronavigation, spinal and pelvic surgery in trauma, hand and reconstructive surgery, oncology, especially in the field of urology and various areas of reconstructive dentistry such as dental implantology, jaw reconstruction or care with individual dentures.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, students have comprehensive insights into the procedures and devices used in surgical and dental 3D planning, the manufacture of patient-specific implants and dentures, as well as robotics and navigation. You are able to describe the functionalities of the systems involved on the basis of the workflow from data acquisition to intraoperative application-related. One focus is the necessary interdisciplinary networking and the associated interface problems. The students know the advantages and limitations of different procedures in different medical and dental applications. In addition, they can independently develop the knowledge they have acquired and generate new interdisciplinary issues in surgery and digital dentistry combined with engineering.
3	**Recommended prerequisite for participation** Concomitant participation either in the module „Digital Dentistry and Surgical Robotics and Navigation I“ or in the module „ Digital Dentistry and Surgical Robotics and Navigation II” is recommended.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event.

Courses

Course Nr. 18-mt-2090-vl	**Course name** Digital Dentistry and Surgical Robotics and Navigation III	
Instructor Prof. Dr. Dr. Robert Sader	**Type** Lecture	**SWS** 2

Module name Anesthesia I					
Module Nr. 18-mt-2100	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Kai Zacharowski		

1	**Content** Within the scope of the module, basic physiology and anatomy from the areas of: Lung, Nerves, Central Nervous System, Heart, Kidney, Coagulation and Gastrointestinal Tract. Furthermore, selected pathologies and diseases are presented. Based on this, current technologies for monitoring and surveillance of diverse body functions are presented. Emphasis is placed on understanding and interpreting “normal” and pathological measurement results.
2	**Learning objectives / Learning Outcomes** After completing the module, the students have basic knowledge of anatomy and physiology with corresponding reference to disease patterns and their pathophysiology. Through this knowledge, the students are able to assess physiological and pathophysiological measurement results of various devices in context and to understand their indication.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr.	**Course name**		
18-mt-2100-vl	Anesthesia I		
Instructor Prof. Dr. Kai Zacharowski		**Type** Lecture	**SWS** 2

Module name Clinical Aspects ENT & Anesthesia II					
Module Nr. 18-mt-2110	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Kai Zacharowski		

1	**Content** * **ENT:** Consolidation of knowledge in the anatomy, physiology and pathophysiology of the ear. In addition, basic knowledge of phoniatrics is imparted and here the anatomy and function of the larynx and the swallowing apparatus as well as basic aspects of phoniatric diagnostics and therapy are explained. The anatomy and function of the nasal head and sinuses are presented together with the associated diagnostic procedures. In the subject area of neurootology, knowledge of the function of the vestibular apparatus is deepened and associated diagnostic procedures are explained. In the field of surgical assistance in ENT, procedures of computer-assisted navigation, applications of robotics, neuromonitoring and procedures of laser surgery are presented. * **Anesthesia II:** During the module, basic physiology and anatomy from the areas of: Lung, Nervous, Central Nervous System, Heart, Kidney, Coagulation and Gastrointestinal Tract. Furthermore, selected pathologies and diseases are presented. Based on this, current instrument technologies for monitoring and surveillance of diverse body functions are presented. Emphasis is placed on understanding and interpreting "normal" and pathological measurement results.
2	**Learning objectives / Learning Outcomes** The students have acquired basic knowledge of the anatomy, physiology and pathophysiology of the inner ear, nose, larynx and swallowing apparatus in the field of ENT. They know basic diagnostic examination procedures of ENT/phoniatrics. Furthermore, the students have acquired knowledge about the structure and function as well as the application of intraoperative assistance systems in ENT. In the field of anesthesia, the students have acquired basic knowledge in anatomy and physiology with corresponding reference to clinical pictures and their pathophysiology. Through this knowledge, students are able to understand the indication of the use of physiological and pathophysiological diagnostic procedures and can assess measurement results of the discussed diagnostic devices in context.
3	**Recommended prerequisite for participation** "Anesthesia I"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Boenninghaus, H.-G., Lenarz, T. (2012) Otorhinolaryngology. Springer.

Courses

Course Nr. 18-mt-2110-vl	**Course name** Clinical Aspects ENT & Anesthesia II	
Instructor Prof. Dr. Kai Zacharowski	**Type** Lecture	**SWS** 2

Module name Audiology, hearing aids and hearing implants					
Module Nr. 18-mt-2120	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner**		

1	**Content** Students learn basic concepts of audiology and gain knowledge of objective and subjective methods for the diagnosis of hearing disorders. In addition, the various devices used in diagnostics are explained and corresponding standards and guidelines are discussed. In the field of pediatric audiology, procedures and devices for performing newborn hearing screening are presented. The design, function and fitting of conventional technical hearing aids and implantable systems are presented. In addition to signal processing and coding strategies of cochlear implant systems, special features of electric-acoustic stimulation are discussed. Special emphasis is given to the treatment of the specific aspects of electrical stimulation of the auditory sense. Students will learn about the fitting pathway for hearing implants, diagnostic procedures for indication, and strategies for managing adverse events. The fitting and monitoring of cochlear implant systems as well as active hearing implants will be explained. The concepts of rehabilitation and support options for hearing impaired children and adults will be presented.
2	**Learning objectives / Learning Outcomes** After successful completion of the module, students will be familiar with the procedures of subjective and objective audiology and will have learned how the equipment required for the examinations works. They know the advantages and limitations of the various diagnostic procedures in different applications. They have learned the construction, functioning and fitting of conventional technical hearing aids as well as implantable hearing systems. They are able to describe the care process with the various hearing systems and to understand the functionalities of the disciplines involved in their interdisciplinary networking as well as the interface problems. They know the advantages and limitations of the different hearing systems and can name the most important criteria for indication. In addition, they can independently apply their acquired knowledge to interdisciplinary issues of audiology together with the engineering sciences and thus formulate subject-related positions.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 60 min, Standard Grading System) The examination takes place in form of a written exam (duration: 60 minutes). If one can estimate that less than 7 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Kießling J, Kollmeier B, Baumann U. Care with hearing aids and hearing implants. 3rd ed. Thieme; 2017
Courses	

	Course Nr.	Course name		
	18-mt-2120-vl	Audiology, hearing aids and hearing implants		
	Instructor		**Type** Lecture	**SWS** 2

3.5 Optional Additional Subjects

Module name Basics of medical information management					
Module Nr. 18-mt-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner**		

1	**Content** This lecture aims to provide insights into the medical information management focusing on the clinical context. • Basic concepts of hospital information systems (HIS) • Exchange formats in clinical information systems (HL7, HL7-FHIR, DICOM) • Medical data models • Interfaces with clinical research • Basic concepts of medical documentation • Telemedicine / assistive health technology
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are familiar with the terminology of a typical hospital system landscape and understand formats and concepts of interfaces for information exchange.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Pass/Fail Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (30 minutes), documentation, report.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses				
	Course Nr. 18-mt-2130-vl	**Course name** Basics of medical information management		
	Instructor		**Type** Lecture	**SWS** 2

4 Optional Subarea

4.1 Optional Subarea Medical Imaging and Image Processing (BB)

4.1.1 BB - Lectures

Module name Image Processing						
Module Nr. 20-00-0155	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.	
Language German			**Module owner** Prof. Dr. Bernt Schiele			
1	**Content** Fundamentals of image processing: - Image properties - Image transformations - Simple and complex filtering - Image compression, - Segmentation - Classification					
2	**Learning objectives / Learning Outcomes** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.					
3	**Recommended prerequisite for participation**					
4	**Form of examination** Module Eccompanying Examination: • [20-00-0155-iv] (Technical Examination, Written/Oral Examination, Standard BWS)					
5	**Grading** Module Eccompanying Examination: • [20-00-0155-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)					
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.					
7	**Grade bonus compliant to §25 (2)**					

8	**References** - Gonzalez, R.C., Woods, R.E., “”Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997			
Courses				
	Course Nr. 20-00-0155-iv	**Course name** Image Processing		
	Instructor		**Type** Integrated Course	**SWS** 2

Module name					
Computer Graphics I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0040	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** Introduction to basic principles of computer graphics, in particular input and output devices, rendering using OpenGL, ray tracing, illumination modelling, ongoing development in computer grapics.
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are able to understand all components of the graphic pipeline and change variable parts (Vertex-Shader, Fragment-Shader, etc.). They are able to arrange, change and effectively store objects in the 3D-space, as well as appropriately choose the camera and the perspective, and utilize various shading-techniques and lighting-models to adapt all steps on the way to the displayed 2D-Image.
3	**Recommended prerequisite for participation** - Programming - Basic algorithm and data structure - Linear algebra - Analysis - Topics of lecture Visual Computing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0040-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0040-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8 - Additional literature will be given in the lecture.
Courses	

	Course Nr.	Course name		
	20-00-0040-iv	Computer Graphics I		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name					
Deep Learning for Medical Imaging					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1014	5 CP	150 h	105 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr.-Ing. Michael Gösele		

1	**Content** Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.
3	**Recommended prerequisite for participation** - Programming skills - Understanding of Algorithmic design - Linear Algebra - Image Processing / Computer Vision I - Statistical Machine Learning
4	**Form of examination** Module Eccompanying Examination: • [20-00-1014-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1014-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

Courses

Course Nr.	Course name		
20-00-1014-iv	Deep Learning for Medical Imaging		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Integrated Course	3

Module name					
Computer Graphics II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0041	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** Foundations of the various object- and surface-representations in computer graphics. Curves and surfaces (polynomials, splines, RBF) Interpolation and approximation, display techniques, algorithms: de Casteljau, de Boor, Oslo, etc. Volumes and implicit surfaces. visualization techniques, iso-surfaces, MLS, surface rendering, marching cubes. Meshes, mesh compression, mesh simplication, multiscale expansion, subdivision. Pointclouds: rendering techniques, surface reconstruction, voronoi-diagram and delaunay-triangulation.
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are able to handle various object- and surface-representations, i.e., to use, adapt, display (render), and effectively store these objects. This includes mathematical polynomial representations, iso-surfaces, volume representations, implicite surfaces, meshes, subdivision control meshes and pointclouds.
3	**Recommended prerequisite for participation** - Algorithmen und Datenstrukturen - Grundlagen aus der Höheren Mathematik - Graphische Datenverarbeitung I - C / C++
4	**Form of examination** Module Eccompanying Examination: • [20-00-0041-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0041-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Additional literature will be given in the lecture.
Courses	

	Course Nr.	Course name		
	20-00-0041-iv	Computer Graphics II		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Information Visualization and Visual Analytics					
Module Nr. 20-00-0294	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Content

This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.
* Overview of information visualization and Visual Analytics (definitions, models, history)
* Data representation and data transformation
* Mapping of data to visual structures
* Introduction to human cognition
* Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data
* Basic data mining techniques
* Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling
* Evaluation of Visual Analytics Systems

2 Learning objectives / Learning Outcomes

After successfully attending the course, students will be able to
* use information visualization methods for specific data types
* design interactive visualization systems for data from various application domains
* couple visualization and automated methods to solve large-scale data analysis problems
* apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics

chose evaluation methods are used for specific situations and scenarios

3 Recommended prerequisite for participation

Interesse an Methoden der Computergrafik und Visualisierung
Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).

4 Form of examination

Module Eccompanying Examination:
- [20-00-0294-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:
- [20-00-0294-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
May be used in other degree programs.

7 Grade bonus compliant to §25 (2)

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Will be announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age

Courses

	Course Nr.	**Course name**		
	20-00-0294-iv	Information Visualization and Visual Analytics		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Medical Image Processing					
Module Nr. 20-00-0379	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** The lecture consists of two parts. The first half of the lecture describes how devices that yield medical image data (CT, NMR, PET, SPECT, Ultrasound) work. The second half of the lecture covers various image processing techniques that are typically applied to medical images.
2	**Learning objectives / Learning Outcomes** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.
3	**Recommended prerequisite for participation** Basics within Mathematics are highly recommended. Participation in lecture “Bildverarbeitung”.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0379-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0379-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** 1) Heinz Handels: Medizinische Bildverarbeitung 2) 2) Gonzalez/Woods: Digital Image Processing (last edition) 3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a. 2005, ISBN 3-540-24999-0 4) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3

Courses

Course Nr. 20-00-0379-vl	**Course name** Medical Image Processing	
Instructor	**Type** Lecture	**SWS** 2

Module name					
Visualization in Medicine					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0467	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** Medical Image Data; Image Processing; Medical Visualization with VTK; Indirect Volume Visualization; Direct Volume Visualization; Transfer Functions; Interactive Volume Visualization; Illustrative Rendering; Example: Visualization of Tensor Image Data; Example: Visualization of Tree Structures; Example: Virtual Endoscopy; Image-guided Surgery
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with volume visualization techniques. They understand the necessity of image enhancement for the visualization. They can use the "Visualization Toolkit" (VTK) to apply the techniques to implement computing systems for the visualization of medical image data for diagnosis, planning and therapy.
3	**Recommended prerequisite for participation** Useful but not mandatory: GDV I, (Medical) Image processing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0467-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0467-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Preim, Botha: Visual Computing for Medicine

Courses

	Course Nr.	**Course name**		
	20-00-0467-iv	Medical Visualization		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Deep Generative Models					
Module Nr. 20-00-1035	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Content** Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging
2	**Learning objectives / Learning Outcomes** After students have attended the module, they can - Explain the structure and operation of Deep Generative Models (DGM) - Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally - independently construct / implement basic DTMs in a high-level programming language designed for this purpose - Transfer the implementation and application of DTMs to different applications
3	**Recommended prerequisite for participation** - Python Programming - Linear Algebra - Image Processing/Computer Vision I - Statistical Machine Learning
4	**Form of examination** Module Eccompanying Examination: • [20-00-1035-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1035-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B,Sc, Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** No textbooks as such. Online materials will be made available during the course.

Courses

Course Nr. 20-00-1035-iv	**Course name** Deep Generative Models	
Instructor Prof. Dr.-Ing. Michael Gösele	**Type** Integrated Course	**SWS** 4

Module name Virtual and Augmented Reality					
Module Nr. 20-00-0160	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** This course starts to detail the principal concepts of Augmented and Virtual Reality in relation to Computer Graphics and Computer Vision. Starting from here basic principles, methods, algorithms as well as relevant standards are discussed. This includes - VR/AR specific requirements and interfaces - Interaction technologies (e.g. interaction with range camera technologies) - Rendering technologies (in particular real-time rendering) - Web-based VR and AR - Computer-Vision-based Tracking - Augmented Reality with range camera technologies - Augmented Reality on smartphone platforms The technologies will be illustrated and discussed with the results of actual research projects including in application fields „AR-maintenance support“ and „AR/VR based Cultural Heritage presentation“.
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with the challenges and the requirements of Virtual and Augmented reality applications. They know the standards used for the specification of VR/AR-applications. In particular, the students understand the potential of Computer Vision based tracking and they can decide which methods can be applied in with environment.
3	**Recommended prerequisite for participation** Grundlagen der Graphischen Datenverarbeitung (GDV)
4	**Form of examination** Module Eccompanying Examination: • [20-00-0160-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0160-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Dörner, R., Broll, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR / AR)
Courses	

	Course Nr.	Course name		
	20-00-0160-iv	Virtual and Augmented Reality		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Robust Signal Processing With Biomedical Applications					
Module Nr. 18-zo-2090	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Dr.-Ing. Michael Muma		

1 Content

1. Robust Signal Processing and Learning
   - Measuring robustness
   - Robust estimation of the mean and the variance
   - Robust regression models
   - Robust filtering
   - Robust location and covariance estimation
   - Robust clustering and classification
   - Robust time-series and spectral analysis

2. Biomedical Applications
   - Body-worn sensing of physiological parameters
   - Electrocardiogram (ECG)
   - Photoplethysmogram (PPG)
   - Eye research
   - Intracranial Pressure (ICP)
   - Algorithms for cardiac activity monitoring

The lecture covers fundamental topics and recent developments in robust signal processing. Unlike classical signal processing, which relies strongly on the normal (Gaussian) distribution, robust methods can tolerate impulsive noise, outliers and artifacts that are frequently encountered in biomedical applications. Robust signal processing and biomedical application lectures alternate. Exercises revise the theory and apply robust signal processing algorithms to real world data.

2 Learning objectives / Learning Outcomes

Students understand the basics of robust signal processing and data science and are able to apply them to a variety of problems. They are familiar with various biomedical applications and know the causes of artifacts, outliers and impulsive noise. They can apply algorithms for robust regression, cluster analysis, classification and spectral analysis.

3 Recommended prerequisite for participation

Fundamental knowledge of statistical signal processing

4 Form of examination

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

A manuscript and lecture slides can be downloaded via Moodle. Further reading

- Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018.
- Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80.
- Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009.
- Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006.

Courses

Course Nr.	**Course name**		
18-zo-2090-vl	Robust Signal Processing With Biomedical Applications		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Muma		Lecture	3
Course Nr.	**Course name**		
18-zo-2090-ue	Robust Signal Processing With Biomedical Applications		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Muma		Practice	1

Module name Technical performance optimization of radiological diagnostics					
Module Nr. 18-mt-2140	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Thomas Vogl		

1	**Content** In this module, students learn ways to optimize the performance of radiological diagnostics. Common areas of application of projection radiography, computed tomography (CT), magnetic resonance imaging (MRI) and angiography are taught. Limitations of the procedures used in relation to common medical questions are explained. In addition, current research results and research projects in the field of radiological diagnostics are presented and explained to the students. On this basis, a research-oriented module approach with a focus on the technical optimization of a radiological procedure in a typical clinical application will be pursued.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students are familiar with current scientific questions regarding the technical development of radiological-diagnostic procedures. They know common areas of application of radiological procedures in clinical routine and understand their meaningfulness and value. They also know about common problems and limitations of common procedures and can discuss them on a scientific level. They are also able to develop and pursue their own current research hypotheses in the field of technical support for radiological procedures. Another aim of this module is that students discuss scientific questions with clinicians working in radiology and learn the dialog between developers, researchers and users. Finally, the results are presented in a simulated scientific lecture and then discussed.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) The examination form will be announced at the beginning of the course. Possible paths are presentation (25 min), report.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced at the event

Courses

Course Nr.	**Course name**		
18-mt-2140-pj	Technical performance optimization of radiological diagnostics		
Instructor Prof. Dr. Thomas Vogl		**Type** Project Seminar	**SWS** 4

Module name Visual Computing Lab					
Module Nr. 20-00-0418	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** Students work in this lab on selected topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.
2	**Learning objectives / Learning Outcomes** After successful completion of this course, the students will be able to independently analyze and solve a problem in the area of visual computing and to evaluate the results.
3	**Recommended prerequisite for participation** Practical programming skills, e.g. Java, C++ Basic knowledge or interest within Visual Computing Participation in one basic lecture within Visiual Computing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0418-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0418-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in course.

Courses

	Course Nr. 20-00-0418-pr	**Course name** Lab Visual Computing	
	Instructor	**Type** Internship	**SWS** 4

Module name Advanced Visual Computing Lab					
Module Nr. 20-00-0537	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** Students work in this lab on selected advanced topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.
2	**Learning objectives / Learning Outcomes** After successful completion of this course, the students will be able to independently analyze and solve an advanced problem in the area of visual computing and to evaluate the results.
3	**Recommended prerequisite for participation** Programming skills, e.g. Java, C++ Basic knowledge in Visula Computing Participation in at least one basic lectures and one lab in the are of Visual Computing.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0537-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0537-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in lecture.

Courses

Course Nr. 20-00-0537-pr	**Course name** Advanced Visual Computing Lab		
Instructor Prof. Dr.-Ing. Michael Gösele		**Type** Internship	**SWS** 4

Module name Computer-aided planning and navigation in medicine					
Module Nr. 20-00-0677	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Georgios Sakas		

1	**Content** - Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts) - Deeper and/or wider library research originating from the initially provided papers - Critical discussion of the provided topic - Preparation of a presentation (written text and slides) about the topic - Giving a talk in front of a heterogenous (mixed prior knowledge) audience - Interactive discussion after the presentation Learning about methods related to planning and navigation are: segmentation, registration, visualization, simulation, navigation, tracking and others.
2	**Learning objectives / Learning Outcomes** Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.
3	**Recommended prerequisite for participation** Bachelors: >=4th semester Masters: >=1st semester
4	**Form of examination** Module Eccompanying Examination: • [20-00-0677-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0677-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be given in seminar.
Courses	

	Course Nr.	Course name		
	20-00-0677-se	Computer-aided planning and navigation in medicine		
	Instructor		**Type**	**SWS**
	Prof. Dr. Georgios Sakas		Seminar	2

Module name Current Trends in Medical Computing					
Module Nr. 20-00-0468	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** - Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts) - Deeper and/or wider library research originating from the initially provided papers - Critical discussion of the provided topic - Preparation of a presentation (written text and slides) about the topic - Giving a talk in front of a heterogenous (mixed prior knowledge) audience - Interactive discussion after the presentation - Medical application areas include oncology, orthopedics and navigated surgery. Learning about methods related to medical image processing: segmentation, registration, visualization, simulation, navigation, tracking and others.
2	**Learning objectives / Learning Outcomes** Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.
3	**Recommended prerequisite for participation** Bachelor from 4. Semester or Master students.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0468-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0468-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in seminar.
Courses	

	Course Nr. 20-00-0468-se	Course name		
	Instructor		Type Seminar	SWS 2

Module name Visual Analytics: Interactive Visualization of Very Large Data					
Module Nr. 20-00-0268	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** This seminar is targeted at computer science students with an interest in information visualization, in particular the visualization of extremely large data. Students will analyze and present a topic from visual analytics. They will also write a paper about this topic.
2	**Learning objectives / Learning Outcomes** After successfully completing the course, students are able to analyze and understand a scientific problem based on the literature. Students are able to present and discuss the topic.
3	**Recommended prerequisite for participation** Interesse sich mit einer graphisch-analytischen Fragestellung bzw. Anwendung aus der aktuellen Fachliteratur zu befassen. Vorkenntnisse in Graphischer Datenverarbeitung, Informationssysteme oder Informationsvisualisierung
4	**Form of examination** Module Eccompanying Examination: • [20-00-0268-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0268-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 20-00-0268-se	**Course name** Visual Analytics: Interactive Visualization of very large amounts of data	
	Instructor	**Type** Seminar	**SWS** 2

Module name Robust and Biomedical Signal Processing					
Module Nr. 18-zo-2100	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

A series of 3 lectures provides the necessary background on robust signal processing and machine learning:

- Background on robust signal processing
- Robust regression and robust filters for artifact cancellation
- Robust location and covariance estimation and classification

They are followed by two lectures on selected biomedical applications, such as:

- Body-worn sensing of physiological parameters
- Optical heart rate sensing (PPG)
- Signal processing for the electrocardiogram (ECG)
- Biomedical image processing

Students then work in groups to apply robust signal processing algorithms to real-world biomedical data. Depending on the application, the data is either recorded by the students, or provided to them. The group results are presented during a 20-minute presentation. The final assessment is based on the presentation and an oral examination.

2 Learning objectives / Learning Outcomes

3 Recommended prerequisite for participation

Fundamental knowledge of statistical signal processing

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

- Slides can be downloaded via Moodle.

Further reading:

- Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018.
- Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80.
- Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009.
- Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006.

Courses				
	Course Nr. 18-zo-2100-se	**Course name** Robust and Biomedical Signal Processing		
	Instructor Dr.-Ing. Michael Muma		**Type** Seminar	**SWS** 4

Module name Artificial Intelligence in Medicine Challenge					
Module Nr. 18-ha-2010	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Content** Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.
2	**Learning objectives / Learning Outcomes** Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.
3	**Recommended prerequisite for participation** • Basic programming skills in Python • 18-zo-1030 Fundamentals of Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc/MSc (WI-)etit, AUT, DT, KTS BSc/MSc iST MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** • Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001. • Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.

Courses

Course Nr. 18-ha-2010-pj	**Course name** Artificial Intelligence in Medicine Challenge	
Instructor Prof. Dr.-Ing. Christoph Hoog Antink	**Type** Project Seminar	**SWS** 4

4.2 Optional Subarea Radiophysics and Radiation Technology in Medical Applications (ST)

4.2.1 ST - Lectures

Module name Physics III						
Module Nr. 05-11-1032	**Credit Points** 7 CP	**Workload** 210 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.	
Language German			**Module owner**			
1	**Content**					
2	**Learning objectives / Learning Outcomes**					
3	**Recommended prerequisite for participation**					
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)					
6	**Usability of this module**					
7	**Grade bonus compliant to §25 (2)**					
8	**References**					
Courses						
	Course Nr. 05-11-0302-vl	**Course name** Physics III				
	Instructor			**Type** Lecture	**SWS** 4	
	Course Nr. 05-13-0302-ue	**Course name** Physics III				
	Instructor			**Type** Practice	**SWS** 2	

Module name Medical Physics					
Module Nr. 05-23-2019	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. Marco Durante		

1 Content

The course covers the applications of physics in medicine, especially in the field of ionising radiation and diagnostic and therapy in oncology.
Following topics will be covered:
X-ray imaging
Nuclear medicine: imaging (SPECT, PET) and therapy with radionuclides
Imaging with non-ionising radiation: ultrasounds, MRI
Radiation therapy
Particle therapy
Radiation protection
Monte Carlo calculations

2 Learning objectives / Learning Outcomes

The students will understand the principle of physics applications in medicine, especially in radiology and radiotherapy. The course is an introduction for students interested in research in biomedical physics and occupation in clinics as medical physicists or health physicists.

3 Recommended prerequisite for participation

recommended “Radiation Biophysics” (Strahlenbiophysik)

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Duration: 120 min, Pass/Fail Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

To be announced during the course.

Courses

Course Nr. 05-21-2019-vl	**Course name**		
Instructor		**Type** Lecture	**SWS** 3

Course Nr. 05-23-2019-ue	**Course name**		
Instructor		**Type** Practice	**SWS** 1

Module name Accelerator Physics					
Module Nr. 18-bf-2010	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Oliver Boine-Frankenheim		

1	**Content** Beam dynamics in linear- and circular accelerators, working principles of different accelerator types and of accelerator components, measurement of beam properties, high-intensity effects and beam current limits.
2	**Learning objectives / Learning Outcomes** The students will learn the working principles of modern accelerators. The design of accelerator magnets and radio-frequency cavities will discussed. The mathematical foundations of beam dynamics in linear and circular accelerators will be introduced. Finally the origin of beam current limitations will be explained.
3	**Recommended prerequisite for participation** BSc in ETiT or Physics
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Physics
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes, transparencies

Courses

	Course Nr. 18-bf-2010-vl	**Course name** Accelerator Physics		
	Instructor Prof. Dr. Oliver Boine-Frankenheim		**Type** Lecture	**SWS** 2

Module name Computational Physics					
Module Nr. 05-11-1505	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner**		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Special Form, Pass/Fail Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Special Form, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 05-11-1932-vl	**Course name** Computational Physics		
	Instructor		**Type** Lecture	**SWS** 2
	Course Nr. 05-13-1932-ue	**Course name** Computational Physics		
	Instructor		**Type** Practice	**SWS** 2

Module name Laser Physics: Fundamentals					
Module Nr. 05-21-2855	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Thomas Halfmann		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Pass/Fail Grading System) The type of examination is announced at the beginning of the course. It can be either (i) a written exam (K, 90 min), (ii) an oral examination (mP, 30 min), or (iii) a presentation (Pt).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 05-21-3032-vl	**Course name** Laser Physics: Fundamentals		
Instructor		**Type** Lecture	**SWS** 3
Course Nr. 05-22-3032-ue	**Course name** Laser Physics: Fundamentals		
Instructor		**Type** Practice	**SWS** 1

Module name Laser Physics: Applications					
Module Nr. 05-21-2856	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. phil. Thomas Walther		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Pass/Fail Grading System) The type of examination is announced at the beginning of the course. It can be either (i) a written exam (K, 90 min), (ii) an oral examination (mP, 30 min), or (iii) a presentation (Pt).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 05-21-2102-vl	**Course name** Laser Physics: Applications		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 05-23-2102-ue	**Course name**		
	Instructor		**Type** Practice	**SWS** 1

Module name Measurement Techniques in Nuclear Physics					
Module Nr. 05-21-1434	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner**		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Pass/Fail Grading System) The type of examination is announced at the beginning of the course. It can be either (i) a written exam (K, 90 min), (ii) an oral examination (mP, 30 min), or (iii) a presentation (Pt).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 05-21-2111-vl	**Course name** Measurement Techniques in Nuclear Physics		
Instructor		**Type** Lecture	**SWS** 3
Course Nr. 05-23-2111-ue	**Course name** Measurement Techniques in Nuclear Physics		
Instructor		**Type** Practice	**SWS** 1

Module name					
Radiation Biophysics					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
05-27-2980	5 CP	150 h	90 h	1	Every 2. Sem.
Language			**Module owner**		
English					

1	**Content** Physical and biological principles of radiation biophysics, introduction to modern experimental techniques in radiation biology. The interaction of ion beams with biological systems is specifically addressed. All steps required to perform ion beam therapy are presented. The following areas are discussed: electromagnetic radiation, particle-matter interaction. Biological aspects: Radiation effects of weak ionizing radiation (e.g. X-rays) on DNA, chromosomes, trace structure of heavy ions. (LET: Linear Energy Transfer) Low-LET radiation biology: effects in the cell, high-LET (e.g. ions) radiation biology, physical and biological dosimetry, effects at low dose, ion beam therapy, therapy models, treatment of moving targets.
2	**Learning objectives / Learning Outcomes** The students are familiar with the physical principles of the interaction of ionizing radiation with matter, its biochemical consequences such as radiation damage in the cell, organs and tissue. Students are familiar with the important applications of radiation biology, e.g., radiation therapy and radiation protection. They are also familiar with the effects of radiation in the environment and in space. The students are able to embed the technical content in the social context, to critically assess the consequences and to act ethically and responsibly accordingly.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Pass/Fail Grading System) The type of examination is announced at the beginning of the course. It can be either (i) a written exam (K, 90 min), (ii) an oral examination (mP, 30 min), or (iii) a presentation (Pt).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** To be announced during the course, for example Eric Hall , Radiobiology for the Radiologist, Lippincott Company

Courses

Course Nr. 05-21-1662-vl	**Course name** Radiation Biophysics		
Instructor		**Type** Lecture	**SWS** 3
Course Nr. 05-23-1662-ue	**Course name** Radiation Biophysics		
Instructor		**Type** Practice	**SWS** 1

4.2.2 ST - Labs and (Project-)Seminars / Problem-oriented Learning

Module name Seminar Radiation Physics and Technology in Medicine					
Module Nr. 18-mt-2150	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner**		

1 Content

- Independent study of current specialist literature, conference and journal papers from the field of radiotherapy and nuclear medicine on a selected topic in the area of basic methods.
- Critical examination of the topic dealt with
- Own further literature research
- Preparation of a lecture (written paper and slide presentation) on the topic dealt with
- Presentation of the lecture to an audience with heterogeneous prior knowledge
- Professional discussion of the topic after the lecture

2 Learning objectives / Learning Outcomes

The students independently acquire in-depth knowledge of aspects of modern radiotherapy or nuclear medicine based on current scientific articles, standards and reference books. In doing so, they learn how to search for and evaluate relevant scientific literature. You can analyse and assess complex physical, technical and scientific information and present it in the form of a summary. The acquired knowledge can be presented in front of a heterogeneous audience and a professional discussion can be held on the acquired knowledge.

3 Recommended prerequisite for participation

Radiotherapy I; Nuclear Medicine

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Biomedical Engineering

7 Grade bonus compliant to §25 (2)

8 References

Will be announced at the beginning of the course.

Courses

Course Nr. 18-mt-2150-se	**Course name** Seminar Radiation Physics and Technology in Medicine		
Instructor		**Type** Seminar	**SWS** 2

Module name Project Seminar Electromagnetic CAD					
Module Nr. 18-sc-1020	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1	**Content** Work on a more complex project in numerical field calculation using commercial tools or own software.
2	**Learning objectives / Learning Outcomes** Students will be able to simulate complex engineering problems with numerical field simulation software. They are able to estimate modelling and numerical errors. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, knowledge about numerical simulation methods.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Course notes “Computational Electromagnetics and Applications I-III”, further material is provided.

Courses

Course Nr. 18-sc-1020-pj	**Course name** Project Seminar Electromagnetic CAD	
Instructor Prof. Dr. rer. nat. Sebastian Schöps	**Type** Project Seminar	**SWS** 4

Module name Project Seminar Particle Accelerator Technology					
Module Nr. 18-kb-1020	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 210 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Harald Klingbeil		

1	**Content** Work on a more complex project in the field of particle accelerator technology. Depending on the specific problem, measurement aspects, analytical aspects, and simulation aspects will be included.
2	**Learning objectives / Learning Outcomes** Students will be able to solve complex engineering problems with different measurement techniques, analytical approaches or simulation methods. They are able to estimate measurement errors and modeling and simulation errors. They know how to present the results on a scientific level in talks and a paper. Students are able to organize teamwork.
3	**Recommended prerequisite for participation** Good understanding of electromagnetic fields, broad knowledge of different electrical engineering disciplines.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Suitable material is provided based on specific problem.

Courses

Course Nr. 18-kb-1020-pj	**Course name** Project Seminar Particle Accelerator Technology	
Instructor Prof. Dr.-Ing. Harald Klingbeil	**Type** Project Seminar	**SWS** 4

Module name Biomedical Microwave-Theranostics: Sensors and Applicators					
Module Nr. 18-jk-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Application of biomedical sensors based on electromagnetic waves and their advantages. Fundamentals of microfluidics as tool for microwave-based sensing of fluids, electroporation; diagnostic and therapeutic applications of microwaves, microwave applicators for imaging, diagnosis and treatment; computer-based methods for field propagation in biological tissues and those applications. Work on a current scientific issue with individual supervision.
2	**Learning objectives / Learning Outcomes** Students understand the physical basics of microwave-based sensors for biomedicine. They are able to derive the advantages of the use of microwaves compared to other technologies. They know fields of applications concerning microwave-based diagnostics and treatments and can handle the physical context of used applicators. Practical examples lead to strenghtening these abilities. Students know computer-based simulation tools for the design and characterization of microwave applicators. They gained experience while working on a practical example with such a simulation software. Students are able to solve manageable scientific problems within the frame of a coordinated project work. They can summarize the current state of the art and write a scientific paper about it. The results are presented and discussed in a final presentation.
3	**Recommended prerequisite for participation** Biomedical Microwave Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (10 minutes) and an oral examination (30 minutes).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Necessary publications and recommended literature as well as simulation software tools are provided.

Courses

	Course Nr. 18-jk-2120-pj	**Course name** Biomedical Microwave-Theranostics: Sensors and Applicators	
	Instructor Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler	**Type** Project Seminar	**SWS** 3

4.3 Optional Subarea Digital Dentistry and Surgical Robotics and Navigation (DC)

4.3.1 DC - Lectures

Module name Foundations of Robotics					
Module Nr. 20-00-0735	**Credit Points** 10 CP	**Workload** 300 h	**Self study** 210 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Content** This course covers spatial representations and transformations, manipulator kinematics, vehicle kinematics, velocity kinematics, Jacobian matrix, robot dynamcis, robot sensors and actuators, robot control, path planning, localization and navigation of mobile robots, robot autonomy and robot development. Theoretical and practical assignments as well as programming tasks serve for deepening of the understanding of the course topics.
2	**Learning objectives / Learning Outcomes** After successful participation, students possess the basic technical knowledge and methodological skills necessary for fundamental investigations and engineering developments in robotics in the fields of modeling, kinematics, dynamics, control, path planning, navigation, perception and autonomy of robots.
3	**Recommended prerequisite for participation** Recommended: basic mathematical knowledge and skills in linear algebra, multi-variable analysis and fundamentals of ordinary differential equations
4	**Form of examination** Module Eccompanying Examination: • [20-00-0735-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0735-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**
Courses	

	Course Nr. 20-00-0735-iv	**Course name** Foundations of Robotics		
	Instructor Prof. Dr. rer. nat. Oskar von Stryk		**Type** Integrated Course	**SWS** 6

Module name Robot Learning					
Module Nr. 20-00-0629	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner**		

1	**Content** - Foundations from robotics and machine learning for robot learning - Learning of forward models - Representation of a policy, hierarchical abstraction wiith movement primitives - Imitation learning - Optimal control with learned forward models - Reinforcement learning and policy search - Inverse reinforcement learning
2	**Learning objectives / Learning Outcomes** Upon successful completion of this course, students are able to understand the relevant foundations of machine learning and robotics. They will be able to use machine learning approaches to empower robots to learn new tasks. They will understand the foundations of optimal decision making and reinforcement learning and can apply reinforcement learning algorithms to let a robot learn from interaction with its environment. Students will understand the difference between Imitation Learning, Reinforcement Learning, Policy Search and Inverse Reinforcement Learning and can apply each of this approaches in the appropriate scenario.
3	**Recommended prerequisite for participation** Good programming in Matlab Lecture Machine Learning 1 - Statistical Approaches is helpful but not mandatory.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0629-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0629-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

Deisenroth, M. P.; Neumann, G.; Peters, J. (2013). A Survey on Policy Search for Robotics, Foundations and Trends in Robotics
Kober, J; Bagnell, D.; Peters, J. (2013). Reinforcement Learning in Robotics: A Survey, International Journal of Robotics Research
C.M. Bishop, Pattern Recognition and Machine Learning (2006),
R. Sutton, A. Barto. Reinforcement Learning - an Introduction
Nguyen-Tuong, D.; Peters, J. (2011). Model Learning in Robotics: a Survey

Courses

Course Nr.	**Course name**		
20-00-0629-vl	Robot Learning		
Instructor		**Type**	**SWS**
		Lecture	4

Module name Mechatronic Systems Engineering I					
Module Nr. 16-24-5020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Stephan Rinderknecht		

1	**Content** Structural dynamics for mechatronic systems; control strategies for mechatronic systems; components for mechatronic systems: actuators, amplifier, controllers, microprocessors, sensors.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Model the structural dynamic components. • Design the best suited controllers for rigid and elastic system components. • Simulate complete mechatronic systems (control loops) under simplified considerations for actuators and sensors. • Explain the static and dynamic behaviour of the mechatronic system.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System) Oral exam 20 min
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** WPB Master MPE II (Kernlehrveranstaltungen aus dem Maschinenbau) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
7	**Grade bonus compliant to §25 (2)**
8	**References** lectures notes

Courses

Course Nr. 16-24-5020-vl	**Course name** Mechatronic Systems in Mechanical Engineering I		
Instructor		**Type** Lecture	**SWS** 2
Course Nr. 16-24-5020-ue	**Course name** Mechatronic Systems in Mechanical Engineering I		
Instructor		**Type** Practice	**SWS** 2

Module name Human-mechatronics systems					
Module Nr. 16-24-3134	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Dr.-Ing. Philipp Beckerle		

1	**Content** This course intends to convey both technical and human-oriented aspects of mechatronic systems that work close to humans. The technology-oriented part of the lecture focuses on the modeling, design, and control of elastic and wearable mechatronic and robotic systems. Research-related topics such as the design of energy-efficient actuators and controllers, body-attached measurement technology, and fault-tolerant human-machine/robot interaction will be included. The focus of the human-oriented part is on the analysis of users' demands and the consideration of such human factors in component and system development. To deepen the contents, flip-the-classroom sessions will be conducted in which relevant research results will be presented and discussed by the students. Human-mechatronics systems; wearable robotic systems; human-oriented design methods; biomechanics; biomechanical models; elastic robots; elastic drives; elastic robot control; human-robot interaction; system integration; fault handling; empirical research methods.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: 1.Tackle challenges in human-mechatronic systems design interdisciplinary 2.Use engineering methods for modeling, design, and control in human-mechatronic systems development. 3. Apply methods from psychology (perception, experience), biomechanics (motion and human models), and engineering (design methodology) and interpret their results. 4.Develop mechatronic and robotic systems that are provide user-oriented interaction characteristics in addition to efficient and reliable operation.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** - Ott, C. (2008). Cartesian impedance control of redundant and flexible-joint robots. Springer. - Whittle, M. W. (2014). Gait analysis: an introduction. Butterworth-Heinemann. - Burdet, E., Franklin, D. W., & Milner, T. E. (2013). Human robotics: neuromechanics and motor control. MIT press. - Gravetter, F. J., & Forzano, L. A. B. (2018). Research methods for the behavioral sciences. Cengage Learning.

Courses

	Course Nr.	Course name		
	16-24-3134-vl	Human-mechatronics systems		
	Instructor		**Type**	**SWS**
			Lecture	2

Module name System Dynamics and Automatic Control Systems III					
Module Nr. 18-ad-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Content

Topics covered are:

- basic properties of non-linear systems,
- limit cycles and stability criteria,
- non-linear control of linear systems,
- non-linear control of non-linear systems,
- observer design for non-linear systems

2 Learning objectives / Learning Outcomes

After attending the lecture, a student is capable of:

- explaining the fundamental differences between linear and non-linear systems,
- testing non-linear systems for limit cycles,
- stating different definitions of stability and testing the stability of equilibria,
- recalling the pros and cons of non-linear controllers for linear systems,
- recalling and applying different techniques for controller design for non-linear systems,
- designing observers for non-linear systems

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Systemdynamik und Regelungstechnik III (available for purchase at the FG office)

Courses

Course Nr. 18-ad-2010-vl	**Course name** System Dynamics and Automatic Control Systems III	
Instructor Prof. Dr.-Ing. Jürgen Adamy	**Type** Lecture	**SWS** 2

Course Nr. 18-ad-2010-ue	**Course name** System Dynamics and Automatic Control Systems III	
Instructor Prof. Dr.-Ing. Jürgen Adamy	**Type** Practice	**SWS** 1

Module name Mechanics of Elastic Structures I					
Module Nr. 16-61-5020	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr.-Ing. Wilfried Becker		

1 Content

Fundamentals (stress state, strain, constitutive material behaviour); In-plane problems (bipotential equation, solutions, examples); bending plate problems (Kirchhoff's plate theory, solutions, othotropic plates, Mindlin's plate theory); planar laminates (single ply behaviour, classical laminate plate theory, hygrothermal problems).

2 Learning objectives / Learning Outcomes

On successful completion of this module, students should be able to:

- Derive and formulate the fundamental relations of the theory of elasticity.
- Formulate and solve elasticity theoretical boundary value problems.
- Derive and apply Airy's stress function relation, in particular for simple technically relevant problems like the plate with a circular hole.
- Apply Kirchhoff's plate theory to simple plate problems, for instance in the form of Navier's solution or Levy's solution.
- Apply classical laminate theory to simple problems of plane multilayer composite problems, also for the case of hygrothermal loading.

3 Recommended prerequisite for participation

Engineering Mechanics 1-3 recommended

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Oral exam including written parts 30 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

WPB Master MPE II (Kernlehrveranstaltungen aus dem Maschinenbau)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
Master Computational Engineering
Master Mechanik

7 Grade bonus compliant to §25 (2)

8 References

W. Becker , W., Gross, D.: Mechanik elastischer Körper und Strukturen. Springer-Verlag, Berlin, 2002; D. Gross, W. Hauger, W. Schnell, P. Wriggers: Technische Mechanik, Band 4: Hydromechanik, Elemente der Höheren Mechanik, numerische Methoden", Springer Verlag, Berlin, 1. Auflage 1993, 5. Auflage 2004

Courses

Course Nr. 16-61-5020-vl	**Course name** Mechanics of Elastic Structures I		
Instructor		**Type** Lecture	**SWS** 3

	Course Nr.	Course name		
	16-61-5020-ue	Mechanics of Elastic Structures I		
	Instructor		**Type**	**SWS**
			Practice	1

Module name Mechanical Properties of Ceramic Materials					
Module Nr. 11-01-9332	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr.-Ing. Jürgen Rödel		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-9332-vl	**Course name**	
	Instructor	**Type** Lecture	**SWS** 2

Module name Technology of Nanoobjects					
Module Nr. 11-01-2021	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. rer. nat. Wolfgang Ensinger		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-2021-vl	**Course name**	
	Instructor	**Type** Lecture	**SWS** 2

Module name Micromechanics and Nanostructured Materials					
Module Nr. 11-01-7070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr.-Ing. Karsten Durst		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 15 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-7070-vl	**Course name**		
	Instructor		**Type** Lecture	**SWS** 2

Module name Interfaces: Wetting and Friction					
Module Nr. 11-01-2016	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. rer. nat. Robert Stark		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 11-01-2016-vl	**Course name**		
Instructor		**Type** Lecture	**SWS** 2

Module name Ceramic Materials: Syntheses and Properties. Part II					
Module Nr. 11-01-7342	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Dr. Emanuel Ionescu		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-7342-vl	**Course name** Synthesis and Properties of Ceramic Materials II		
	Instructor		**Type** Lecture	**SWS** 2

Module name Mechanical Properties of Metals					
Module Nr. 11-01-2006	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Apl. Prof. Dr.-Ing. Clemens Müller		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 11-01-9092-vl	**Course name**	
Instructor	**Type** Lecture	**SWS** 2

Module name Design of Human-Machine-Interfaces					
Module Nr. 16-21-5040	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ralph Bruder		

1	**Content** Case studies of human-machine-interfaces, basics of system theory, user modelling, human-machine-interaction, interface-design, usability.
2	**Learning objectives / Learning Outcomes** On successful completion of this module, students should be able to: • Reflect the technical development of human-machine interfaces using examples • Describe human-machine interfaces in system theoretical terminology • Explain models of human information processing and the related application issues • Apply the human-centered product development process in accordance with DIN EN ISO 9241-210 • Analyse the use context of products for the deduction of user requirements • Implement the design criterias using the guidelines for the design of human-machine systems • Assess the usability of products using methods with and without user involvement
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Standard Grading System) Written exam 90 min
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** WP Bachelor MPE Bachelor Mechatronik
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture notes available on the internet (www.arbeitswissenschaft.de)

Courses

	Course Nr. 16-21-5040-vl	**Course name** Design of Human-Machine-Interfaces		
	Instructor		**Type** Lecture	**SWS** 3
	Course Nr. 16-21-5040-ue	**Course name** Design of Human-Machine-Interfaces		
	Instructor		**Type** Practice	**SWS** 1

Module name Surface Technologies I					
Module Nr. 16-08-5060	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Dr.-Ing. Torsten Troßmann		

1	**Content** Introduction to surface technology; definitions; surface functions; technical surfaces; corrosion mechanisms: chemical, electro-chemical and metallurgical corrosion; thermodynamics and kinetics of corrosion; passivation, manifestations of electro-chemical corrosion: planar corrosion, local corrosion, selective corrosion; corrosion under simultaneous mechanical loading; electro-chemical methods to detect and quantify corrosion; corrosion testing; active and passive corrosion protection methods; tribo-systems, tribological loading states, friction and friction mechanisms, wear and wear mechanisms, measures to quantify wear and tribological testing measures.
2	**Learning objectives / Learning Outcomes** After following this lecture the student will be able to • Evaluate and categorize primary and secondary functions of component surfaces. • Explain the differences and mechanisms of the various corrosion processes. • Apply thermodynamic and kinetic principles describing electro-chemical corrosion processes. • Assess the appearance of electro-chemical corrosion reactions. • Evaluate methods to capture and quantify corrosion and recommend testing measures for a given task. • Describe active and passive corrosion protection measures and recommend suitable measures for a given application. • Describe the constituents of a tribo-system. • Describe wear and wear mechanisms and assess the wear mechanism for a given wear damage. • Recommend measures to modify the wear behavior.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Standard Grading System) Oral exam 30 min or written exam 35 min
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)
6	**Usability of this module** WPB Master MPE II (Kernlehrveranstaltungen aus dem Maschinenbau) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
7	**Grade bonus compliant to §25 (2)**
8	**References** M. Oechsner: Umdruck zur Vorlesung (Foliensätze). H. Kaesche, Korrosion der Metalle (Springer Verlag) K. Bobzin, Oberflächentechnik für den Maschinenbau (Wiley-VCH) E. Wendler-Kalsch, Korrosionsschadenkunde (VDI-Verlag)
Courses	

	Course Nr.	Course name		
	16-08-5060-vl	Surface Technologies I		
	Instructor		**Type**	**SWS**
			Lecture	3

Module name Surface Technologies II					
Module Nr. 16-08-5070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Dr.-Ing. Torsten Troßmann		

1 Content

The student will learn about the application of surface technologies to improve highly loaded component surfaces regarding their functionality in an efficient way. By means of various examples, the student will learn to select the most suitable coating application technique, in particular within the context to address a multitude of functional requirements and specific properties. In order to do so, the impact of variations of the deposition process parameter on the coating properties needs to be understood. The lecture will discuss various coating deposition processes with application examples: galvanic deposition, dip coating processes, mechanical deposition processes, conversion layers, painting technologies, anodisation, PVD- and CVD thin film technologies, sol-gel coatings, and thermal spray coatings. In addition, the relevant technical boundaries for a successful application of coatings, e.g. coating process relevant component design guidelines.

2 Learning objectives / Learning Outcomes

After following this lecture the student will be able to

- Evaluate and categorize primary and secondary functions of component surfaces.
- Explain principles of coating – substrate adhesion.
- Explain relevant pre- and post deposition processes regarding their working principle and associate them to specific deposition techniques.
- Explain and describe potential coating – substrate interactions.
- Explain experimental techniques on how to quantify and assess adhesion properties of coatings and recommend suitable measures for a given coating- and loading scenario.
- Explain characteristics to describe the coat-ability of surfaces.
- Derive principles on the requirements of the component surface topology and geometry regarding the suitability of various coating deposition techniques.
- Describe the surface modification and coating processes working principles, the equipment, the coating architecture, the operational boundary conditions, and the relevant process parameters.
- Recommend a coating process for a given component under a given load scenario.

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Standard Grading System)

Oral exam 30 min or written exam 45 min

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Technical Examination, Weighting: 100 %)

6 Usability of this module

WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)

7 Grade bonus compliant to §25 (2)

8 References

M. Oechsner: Umdruck zur Vorlesung (Foliensätze).
K. Bobzin, Oberflächentechnik für den Maschinenbau (Wiley-VCH)
H. Hofmann und J. Spindler, Verfahren in der Beschichtungs- und Oberflächentechnik (Hanser)

Courses				
	Course Nr. 16-08-5070-vl	**Course name** Surface Technologies II		
	Instructor		**Type** Lecture	**SWS** 3

Module name Image Processing					
Module Nr. 20-00-0155	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** Fundamentals of image processing: - Image properties - Image transformations - Simple and complex filtering - Image compression, - Segmentation - Classification
2	**Learning objectives / Learning Outcomes** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern image processing techniques. They are able to solve basic to medium level problems in image processing.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-0155-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0155-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** - Gonzalez, R.C., Woods, R.E., “”Digital Image Processing"", Addison- Wesley Publishing Company, 1992 - Haberaecker, P., ""Praxis der Digitalen Bildverarbeitung und Mustererkennung"", Carl Hanser Verlag, 1995 - Jaehne, B., ""Digitale Bildverarbeitung"", Springer Verlag, 1997

Courses

Course Nr.	Course name		
20-00-0155-iv	Image Processing		
Instructor		**Type** Integrated Course	**SWS** 2

Module name					
Deep Learning for Medical Imaging					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1014	5 CP	150 h	105 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr.-Ing. Michael Gösele		

1 Content

Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.

2 Learning objectives / Learning Outcomes

After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.

3 Recommended prerequisite for participation

- Programming skills
- Understanding of Algorithmic design
- Linear Algebra
- Image Processing / Computer Vision I
- Statistical Machine Learning

4 Form of examination

Module Eccompanying Examination:

- [20-00-1014-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-1014-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

7 Grade bonus compliant to §25 (2)

In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.

8 References

Courses

Course Nr.	Course name		
20-00-1014-iv	Deep Learning for Medical Imaging		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Integrated Course	3

Module name					
Computer Graphics I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0040	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** Introduction to basic principles of computer graphics, in particular input and output devices, rendering using OpenGL, ray tracing, illumination modelling, ongoing development in computer grapics.
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are able to understand all components of the graphic pipeline and change variable parts (Vertex-Shader, Fragment-Shader, etc.). They are able to arrange, change and effectively store objects in the 3D-space, as well as appropriately choose the camera and the perspective, and utilize various shading-techniques and lighting-models to adapt all steps on the way to the displayed 2D-Image.
3	**Recommended prerequisite for participation** - Programming - Basic algorithm and data structure - Linear algebra - Analysis - Topics of lecture Visual Computing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0040-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0040-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Real-Time Rendering: Tomas Akenine-Möller, Eric Haines, Naty Hoffman A.K. Peters Ltd., 3rd edition, ISBN 987-1-56881-424-7 - Fundamentals of Computer Graphics: Peter Shirley, Steve Marschner, third edition, ISBN 979-1-56881-469-8 - Additional literature will be given in the lecture.
Courses	

	Course Nr.	Course name		
	20-00-0040-iv	Computer Graphics I		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name					
Medical Image Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0379	3 CP	90 h	60 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** The lecture consists of two parts. The first half of the lecture describes how devices that yield medical image data (CT, NMR, PET, SPECT, Ultrasound) work. The second half of the lecture covers various image processing techniques that are typically applied to medical images.
2	**Learning objectives / Learning Outcomes** After successfully completing the course, students have an overview over the mechanisms used in and the abilities of modern medical image processing techniques. They are able to solve basic to medium level problems in medical image processing.
3	**Recommended prerequisite for participation** Basics within Mathematics are highly recommended. Participation in lecture “Bildverarbeitung”.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0379-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0379-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** 1) Heinz Handels: Medizinische Bildverarbeitung 2) 2) Gonzalez/Woods: Digital Image Processing (last edition) 3) 3) Bernd Jähne: Digitale Bildverarbeitung. 6. überarbeitete und erweiterte Auflage. Springer, Berlin u. a. 2005, ISBN 3-540-24999-0 4) Kristian Bredies, Dirk Lorenz: Mathematische Bildverarbeitung. Einführung in Grundlagen und moderne Theorie. Vieweg+Teubner, Wiesbaden 2011, ISBN 978-3-8348-1037-3

Courses

Course Nr.	Course name		
20-00-0379-vl	Medical Image Processing		
Instructor		**Type**	**SWS**
		Lecture	2

Module name					
Visualization in Medicine					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0467	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. Bernt Schiele		

1	**Content** Medical Image Data; Image Processing; Medical Visualization with VTK; Indirect Volume Visualization; Direct Volume Visualization; Transfer Functions; Interactive Volume Visualization; Illustrative Rendering; Example: Visualization of Tensor Image Data; Example: Visualization of Tree Structures; Example: Virtual Endoscopy; Image-guided Surgery
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with volume visualization techniques. They understand the necessity of image enhancement for the visualization. They can use the "Visualization Toolkit" (VTK) to apply the techniques to implement computing systems for the visualization of medical image data for diagnosis, planning and therapy.
3	**Recommended prerequisite for participation** Useful but not mandatory: GDV I, (Medical) Image processing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0467-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0467-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Preim, Botha: Visual Computing for Medicine

Courses

Course Nr. 20-00-0467-iv	**Course name** Medical Visualization		
Instructor		**Type** Integrated Course	**SWS** 4

Module name Virtual and Augmented Reality					
Module Nr. 20-00-0160	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** This course starts to detail the principal concepts of Augmented and Virtual Reality in relation to Computer Graphics and Computer Vision. Starting from here basic principles, methods, algorithms as well as relevant standards are discussed. This includes - VR/AR specific requirements and interfaces - Interaction technologies (e.g. interaction with range camera technologies) - Rendering technologies (in particular real-time rendering) - Web-based VR and AR - Computer-Vision-based Tracking - Augmented Reality with range camera technologies - Augmented Reality on smartphone platforms The technologies will be illustrated and discussed with the results of actual research projects including in application fields „AR-maintenance support“ and „AR/VR based Cultural Heritage presentation“.
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with the challenges and the requirements of Virtual and Augmented reality applications. They know the standards used for the specification of VR/AR-applications. In particular, the students understand the potential of Computer Vision based tracking and they can decide which methods can be applied in with environment.
3	**Recommended prerequisite for participation** Grundlagen der Graphischen Datenverarbeitung (GDV)
4	**Form of examination** Module Eccompanying Examination: • [20-00-0160-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0160-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Dörner, R., Broll, W., Grimm, P., Jung, B. Virtual und Augmented Reality (VR / AR)
Courses	

	Course Nr.	Course name		
	20-00-0160-iv	Virtual and Augmented Reality		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Information Visualization and Visual Analytics					
Module Nr. 20-00-0294	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Bernt Schiele		

1 Content

This lecture will give a detailed introduction to the scientific topics of information visualization and Visual Analytics, and will cover current research areas as well as practical application scenarios of Visual Analytics.
* Overview of information visualization and Visual Analytics (definitions, models, history)
* Data representation and data transformation
* Mapping of data to visual structures
* Introduction to human cognition
* Visual representations and interaction for bivariate and multivariate Data, time series, networks and geographic data
* Basic data mining techniques
* Visual Analytics - Analytics reasoning - Data mining - Statistics Analytical techniques and scaling
* Evaluation of Visual Analytics Systems

2 Learning objectives / Learning Outcomes

After successfully attending the course, students will be able to
* use information visualization methods for specific data types
* design interactive visualization systems for data from various application domains
* couple visualization and automated methods to solve large-scale data analysis problems
* apply knowledge about key characteristics of the human visual and cognitive system for information visualization and visual analytics

chose evaluation methods are used for specific situations and scenarios

3 Recommended prerequisite for participation

Interesse an Methoden der Computergrafik und Visualisierung
Die Veranstaltung richtet sich an Informatiker, Wirtschaftsinformatiker, Mathematiker in Bachelor, Master und Diplomstudiengänge und weiteren interessierten Kreisen (z.B. Biologen, Psychologen).

4 Form of examination

Module Eccompanying Examination:
- [20-00-0294-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:
- [20-00-0294-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
May be used in other degree programs.

7 Grade bonus compliant to §25 (2)

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Will be announced in lecture, an example might be: C. Ware: Information Visualization: Perception for Design Ellis et al: Mastering the Information Age

Courses

	Course Nr.	**Course name**		
	20-00-0294-iv	Information Visualization and Visual Analytics		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name Deep Learning: Architectures & Methods					
Module Nr. 20-00-1034	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** * Review of machine learning background * Deep Feedforward Networks * Regularization for Deep Learning * Optimization for Training Deep Models * Convolutional Networks * Sequence Modeling: Recurrent and Recursive Nets * Linear Factor Models * Autoencoders * Representation Learning * Structured Probabilistic Models for Deep Learning * Monte Carlo Methods * Approximate Inference * Deep Generative Models * Deep Reinforcement Learning * Deep Learning in Vision * Deep Learning in NLP
2	**Learning objectives / Learning Outcomes** This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.
3	**Recommended prerequisite for participation** 20-00-0358-iv Statistical Machine Learning 20-00-0052-iv Data Mining and Machine Learning
4	**Form of examination** Module Eccompanying Examination: • [20-00-1034-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1034-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**
Courses	

	Course Nr.	Course name		
	20-00-1034-iv	Deep Learning: Architectures & Methods		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Integrated Course	4

Module name Machine Learning and Deep Learning for Automation Systems					
Module Nr. 18-ad-2100	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Jürgen Adamy		

1 Content

- Concepts of machine learning
- Linear methods
- Support vector machines
- Trees and ensembles
- Training and assessment
- Unsupervised learning
- Neural networks and deep learning
- Convolutional neuronal networks (CNNs)
- CNN applications
- Recurrent neural networks (RNNs)

2 Learning objectives / Learning Outcomes

Students will get a broad and practical view on the field of machine learning. First, the most relevant algorithm classes of supervised and unsupervised learning are discussed. After that, the course addresses deep neural networks, which enable many of today's applications in image and signal processing. The fundamental characteristics of all algorithms are compiled and demonstrated by programming examples. Students will be able to assess the methods and apply them to practical tasks.

3 Recommended prerequisite for participation

Fundamental knowledge in linear algebra and statistics
Preferred: Lecture "Fuzzy logic, neural networks and evolutionary algorithms"

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 7 students register, the examination will be an oral examination (duration: 30 min.). The type of examination will be announced in the beginning of the lecture.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

- T. Hastie et al.: The Elements of Statistical Learning. 2. Aufl., Springer, 2008
- I. Goodfellow et al.: Deep Learning. MIT Press, 2016
- A. Géron: Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow. 2. Aufl., O'Reilly, 2019

Courses

	Course Nr.	Course name		
	18-ad-2100-vl	Machine Learning and Deep Learning for Automation Systems		
	Instructor		**Type**	**SWS**
	Dr.-Ing. Michael Vogt		Lecture	2

Module name Internship in Surgery and Dentistry I					
Module Nr. 18-mt-2160	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The internship includes the clinical applications of surgical robotics and navigation and digital dentistry procedures, especially in the areas of neuronavigation, spinal and pelvic surgery in trauma, hand and reconstructive surgery, oncologic surgery, especially in the field of urology, and various areas of reconstructive dentistry such as dental implantology, jaw reconstruction or the provision of individual dentures. The students are familiarized with the associated software applications and technologies of the associated medical device technologies in their basics and can also carry out initial practical exercises. In selected cases, the clinical use is demonstrated on the patient.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students have first insights into the principles and functions of radiological and non-radiological scanning procedures for generating 3D-patient treatment data, their software-based evaluation, their further use for treatment planning and the technological transfer to the actual treatment situation. They can name the clinical fields of application in surgery and dentistry and the advantages and disadvantages, especially in the areas of neuronavigation, spinal and pelvic surgery, urological oncology, dental implantology and various areas of reconstructive digital dentistry and oral and cranio-maxillofacial surgery. In addition, they can position their acquired knowledge in the context of other interdisciplinary issues in medicine and engineering and thus formulate fundamental subject-related positions.
3	**Recommended prerequisite for participation** Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation I" is recommended.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event.

Courses

Course Nr.	**Course name**		
18-mt-2160-pr	Internship in Surgery and Dentistry I		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Robert Sader		Internship	2

Module name Internship in Surgery and Dentistry II					
Module Nr. 18-mt-2170	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The internship includes the deepend clinical application of procedures in surgical robotics and navigation and digital dentistry, especially in the areas of neuronavigation, spine and pelvic surgery in trauma, hand and reconstructive surgery, in oncologic surgery, especially in the field of urology, and in various areas of reconstructive dentistry such as dental implantology, jaw reconstructions or the supply of individual dentures. The students are made familiar with the associated software applications and technologies of the associated medical device technologies in clinical use and they also carry out practical exercises. In selected cases, clinical use is demonstrated on the patient.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students have comprehensive insights into the principles and functions of radiological and non-radiological scanning methods for generating 3D-patient treatment data, their evaluation, their further use for 3D-treatment planning and the technological transfer to the actual treatment situation. They can name the clinical fields of application in surgery and dentistry and can comprehensively describe the advantages and disadvantages of the different applications for the respective application, especially in the areas of neuronavigation, spinal and pelvic surgery, urological oncology, dental implantology and various areas reconstructive digital dentistry and oral and cranio-maxillofacial surgery. In addition, they can independently apply the knowledge they have acquired to other interdisciplinary issues in medicine and engineering and thus formulate subject-related positions.
3	**Recommended prerequisite for participation** Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation II" is recommended.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event.

Courses

Course Nr.	**Course name**		
18-mt-2170-pr	Internship in Surgery and Dentistry II		
Instructor		**Type**	**SWS**
Prof. Dr. Dr. Robert Sader		Internship	2

Module name Internship in Surgery and Dentistry III					
Module Nr. 18-mt-2180	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Dr. Robert Sader		

1	**Content** The internship includes the comprehensive clinical application of procedures in surgical robotics and navigation and digital dentistry, especially in the areas of neuronavigation, spine and pelvic surgery in the field of trauma, hand and reconstructive surgery, and oncology, especially in the field of urology and various areas of reconstructive dentistry such as dental implantology, jaw reconstructions or the dental care with individual dentures. The students will be familiar with the associated software applications and technologies of the associated medical device technologies that they can independently develop further questions to be solved in the context of a master's or doctoral thesis. For this, they also carry out practical exercises in which different medical products are involved. In selected cases, the clinical use is demonstrated on the patient.
2	**Learning objectives / Learning Outcomes** After successfully completing the module, the students have comprehensive insights into the principles and functions of radiological and non-radiological scanning methods for generating 3D-patient treatment data, their software-based evaluation, their further use for treatment planning and the technological transfer to the actual treatment situation. They know the current clinical fields of application in surgery and dentistry, can describe the advantages and disadvantages of the different applications and can develop problem-solving approaches. This is implemented in particular in the areas of neuronavigation, spine and pelvic surgery, urological oncology, dental implantology and various areas of reconstructive digital dentistry and oral and cranio-maxillofacial surgery. They can independently apply the knowledge they have acquired to other interdisciplinary issues in medicine and engineering and thus can formulate subject-related positions and can develop solutions.
3	**Recommended prerequisite for participation** Concomitant participation in the module „Digital Dentistry and Surgical Robotics and Navigation III" is recommended.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be published during the event.

Courses

Course Nr.	**Course name**		
18-mt-2180-pr	Internship in Surgery and Dentistry III		
Instructor Prof. Dr. Dr. Robert Sader		**Type** Internship	**SWS** 2

Module name Integrated Robotics Project 1					
Module Nr. 20-00-0324	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1 Content

- guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers
- becoming acquainted with the relevant state of research and technology
- development of a solution approach and its implementation
- application and evaluation based on robot experiments or simulations
- documentation of task, approach, implementation and results in a final report and conduction of a final presentation

2 Learning objectives / Learning Outcomes

Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.

3 Recommended prerequisite for participation

- basic knowledge within Robotics as given in lecture “Grundlagen der Robotik”
- programming skills depending on task

4 Form of examination

Module Eccompanying Examination:

- [20-00-0324-pr] (Study Achievement, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-0324-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
May be used in other degree programs.

7 Grade bonus compliant to §25 (2)

8 References

Will be given in lecture.

Courses

Course Nr. 20-00-0324-pr	**Course name** Integrated Robotics Project (Part 1)	
Instructor	**Type** Internship	**SWS** 4

Module name Laboratory Matlab/Simulink I					
Module Nr. 18-ko-1030	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1	**Content** In this lab tutorial, an introduction to the software tool MatLab/Simulink will be given. The lab is split into two parts. First the fundamentals of programming in Matlab are introduced and their application to different problems is trained. In addition, an introduction to the Control System Toolbox will be given. In the second part, the knowledge gained in the first part is applied to solve a control engineering specific problem with the software tools.
2	**Learning objectives / Learning Outcomes** Fundamentals in the handling of Matlab/Simulink and the application to control engineering tasks.
3	**Recommended prerequisite for participation** The lab should be attended in parallel or after the lecture “System Dynamics and Control Systems I”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT; BSc MEC
7	**Grade bonus compliant to §25 (2)** In case of E-Learning: Possibility to improve the grade up to 1,0
8	**References** Lecture notes for the lab tutorial can be obtained at the secretariat Lunze; Regelungstechnik I Dorp; Bishop: Moderne Regelungssysteme Moler: Numerical Computing with MATLAB

Courses

	Course Nr. 18-ko-1030-pr	**Course name** Laboratory Matlab/Simulink I	
	Instructor Prof. Dr.-Ing. Ulrich Konigorski, M.Sc. Alexander Steinke	**Type** Internship	**SWS** 3

Module name Laboratory Control Engineering I					
Module Nr. 18-ko-1020	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Ulrich Konigorski		

1 Content

- Control of a 2-tank system.
- Control of pneumatic and hydraulic servo-drives.
- Control of a 3 mass oscillator.
- Position control of a MagLev system.
- Control of a discrete transport process with electro-pneumatic components.
- Microcontroller-based control of an electrically driven throttle valve.
- Identification of a 3 mass oscillator.
- Process control using PLC.

2 Learning objectives / Learning Outcomes

After this lab tutorial the students will be able to practically apply the modelling and design techniques for different dynamic systems presented in the lecture ”System dynamics and control systems I” to real lab experiments and to bring them into operation at the lap setup.

3 Recommended prerequisite for participation

System Dynamics and Control Systems I

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Weighting: 100 %)

6 Usability of this module

BSc ETiT

7 Grade bonus compliant to §25 (2)

8 References

Lab handouts will be given to students

Courses

Course Nr. 18-ko-1020-pr	**Course name** Laboratory Control Engineering I		
Instructor Prof. Dr.-Ing. Ulrich Konigorski		**Type** Internship	**SWS** 4

Module name					
Project Seminar Robotics and Computational Intelligence					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ad-2070	8 CP	240 h	180 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Jürgen Adamy		

1 Content

The following topics are taught in the lecture:

Industrial robots

- Types and applications
- Geometry and kinematics
- Dynamic model
- Control of industrial robots

Mobile robots

- Types and applications
- Sensors
- Environmental maps and map building
- Trajectory planning

Group projects are arranged in parallel to the lectures in order to apply the taught material in practical exercises.

2 Learning objectives / Learning Outcomes

After attending the lecture, a student is capable of: 1. recalling the basic elements of industrial robots, 2. recalling the dynamic equations of industrial robots and be able to apply them to describe the dynamics of a given robot, 3. stating model problems and solutions to standard problems in mobile robotics, 4. planing a small project, 5. organizing the work load in a project team, 6. searching for additional background information on a given project, 7. creating ideas on how to solve problems arising in the project, 8. writing an scientific report about the outcome of the project 8. presenting the results of the project.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc MEC, MSc iST, MSc WI-ETiT, MSc iCE, MSc EPE, MSc CE, MSc Informatik

7 Grade bonus compliant to §25 (2)

8 References

Adamy: Lecture notes (available for purchase at the FG office)

Courses

Course Nr.	Course name		
18-ad-2070-pj	Project Seminar Robotics and Computational Intelligence		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Jürgen Adamy		Project Seminar	4

Module name Robotics Lab Project					
Module Nr. 20-00-0248	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 180 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Content** - guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers - development of a solution approach and its implementation - application and evaluation based on robot experiments or simulations - documentation of task, approach, implementation and results in a final report and conduction of a final presentation
2	**Learning objectives / Learning Outcomes** Through successful participation students acquire deepened knowledge in selected areas and subsystems of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.
3	**Recommended prerequisite for participation** - basic knowledge within Robotics as given in lecture “Grundlagen der Robotik” - programming skills depending on task
4	**Form of examination** Module Eccompanying Examination: • [20-00-0248-pp] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0248-pp] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 20-00-0248-pp	**Course name** Robotics Project		
Instructor		**Type** Project	**SWS** 6

Module name Visual Computing Lab					
Module Nr. 20-00-0418	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** Students work in this lab on selected topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.
2	**Learning objectives / Learning Outcomes** After successful completion of this course, the students will be able to independently analyze and solve a problem in the area of visual computing and to evaluate the results.
3	**Recommended prerequisite for participation** Practical programming skills, e.g. Java, C++ Basic knowledge or interest within Visual Computing Participation in one basic lecture within Visiual Computing
4	**Form of examination** Module Eccompanying Examination: • [20-00-0418-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0418-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced in course.

Courses

Course Nr. 20-00-0418-pr	**Course name** Lab Visual Computing		
Instructor		**Type** Internship	**SWS** 4

Module name Recent Topics in the Development and Application of Modern Robotic Systems					
Module Nr. 20-00-0148	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. rer. nat. Oskar von Stryk		

1	**Content** - guided independent work on a concrete task from development and application of modern robotic systems - becoming acquainted with the relevant state of research and technology - development of a solution approach and its presentation and discussion in a talk and in a final report
2	**Learning objectives / Learning Outcomes** Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems and train presentation and documentation skills.
3	**Recommended prerequisite for participation** Basic knowledge in Robotics as given in lecture “Grundlagen der Robotik”.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0148-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0148-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be given in lecture.

Courses

Course Nr. 20-00-0148-se	**Course name** Recent Topics in the Development and Application of Modern Robotic Systems	
Instructor	**Type** Seminar	**SWS** 2

Module name Analysis and Synthesis of Human Movements I					
Module Nr. 03-04-0580	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. phil. André Seyfarth		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [03-41-0580-se] (Study Achievement, Optional, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [03-41-0580-se] (Study Achievement, Optional, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 03-41-0580-se	**Course name**	
	Instructor	**Type** Seminar	**SWS** 2

Module name Analysis and Synthesis of Human Movements II					
Module Nr. 03-04-0582	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. phil. André Seyfarth		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [03-41-0582-se] (Study Achievement, Optional, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [03-41-0582-se] (Study Achievement, Optional, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 03-41-0582-se	**Course name**		
	Instructor		**Type** Seminar	**SWS** 2

Module name Computer-aided planning and navigation in medicine					
Module Nr. 20-00-0677	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. Georgios Sakas		

1	**Content** - Participants independently familiarize themselves with a chosen seminar topic by working with the provided initial scientific papers (usually English-language texts) - Deeper and/or wider library research originating from the initially provided papers - Critical discussion of the provided topic - Preparation of a presentation (written text and slides) about the topic - Giving a talk in front of a heterogenous (mixed prior knowledge) audience - Interactive discussion after the presentation Learning about methods related to planning and navigation are: segmentation, registration, visualization, simulation, navigation, tracking and others.
2	**Learning objectives / Learning Outcomes** Successful participation in the course enables students to become acquainted with an unfamilar topic by working with scientific papers. They recognize the essential aspects of the examined works and are able to concisely present them to an audience with mixed prior knowledge on the subject. They apply a number of presentation techniques in the process. The students are able to actively guide and participate in a scientific discussion on the presented topic.
3	**Recommended prerequisite for participation** Bachelors: >=4th semester Masters: >=1st semester
4	**Form of examination** Module Eccompanying Examination: • [20-00-0677-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0677-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be given in seminar.
Courses	

	Course Nr.	Course name		
	20-00-0677-se	Computer-aided planning and navigation in medicine		
	Instructor		**Type**	**SWS**
	Prof. Dr. Georgios Sakas		Seminar	2

4.4 Optional Subarea Actuator Engineering, Sensor Technology; and Neurostimulation (AS)

4.4.1 ASN - Lectures

Module name Sensor Signal Processing					
Module Nr. 18-kn-2130	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. Mario Kupnik		

1	**Content** The module provides knowledge in-depth about the measuring and processing of sensor signals. In the area of primary electronics, some particular characteristics such as errors, noise and intrinsic compensation of bridges and amplifier circuits (carrier frequency amplifiers, chopper amplifiers, Low-drift amplifiers) in terms of error and energy aspects are discussed. Within the scope of the secondary electronic, the classical and optimal filter circuits, modern AD conversion principles and the issues of redundancy and error compensation will be discussed.
2	**Learning objectives / Learning Outcomes** The Students acquire advanced knowledge on the structure of modern sensors and sensor proximity signal processing. They are able to select appropriate basic structure of modern primary and secondary electronics and to consider the error characteristics and other application requirements.
3	**Recommended prerequisite for participation** Measuring Technique, Sensor Technique, Electronic, Digital Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Slide set of lecture • Skript of lecture • Textbook Tränkler „Sensortechnik“, Springer • Textbook Tietze/Schenk „Halbleiterschaltungstechnik“, Springer

Courses

Course Nr. 18-kn-2130-vl	**Course name** Sensor Signal Processing	
Instructor Prof. Dr. Mario Kupnik	**Type** Lecture	**SWS** 2

Module name					
Speech and Audio Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2070	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Abdelhak Zoubir		

1	**Content** Algorithms of speech and audio signal processing: Introduction to the models of speech and audio signals and basic methods of audio signal processing. Procedures of codebook based processing and audio coding. Beamforming for spatial filtering and noise reduction for spectral filtering. Cepstral filtering and fundamental frequency estimation. Mel-filterind cepstral coefficients (MFCCs) as basis for speaker detection and speech recognition. Classification methods based on GMM (Gaussian mixture models) and speech recognition with HMM (Hidden markov models). Introduction to the methods of music signal processing, e.g. Shazam-App or beat detection.
2	**Learning objectives / Learning Outcomes** Based on the lecture you acquire an advanced knowledge of digital audio signal processing mainly with the help of the analysis of speech signals. You learn about different basic and advanced methods of audio signal processing, to range from the theory to practical applications. You will acquire knowledge about algorithms such as they are applied in mobile telephones, hearing aids, hands-free telephones, and man-machine-interfaces (MMI). The exercise will be organized as a talk given by each student with one self-selected topic of speech and audio processing. This will allow you to acquire the know-how to read and understand scientific literature, familiarize with an unknown topic and present your knowledge, such as it will be certainly required from you in your professional life as an engineer.
3	**Recommended prerequisite for participation** Knowlegde about satistical signal processing is required (lecture „Digital Signal Processing“). Desired – but not mandatory – is knowledge about adaptive filters.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System) Seminar presentation: Scientific talk about a topic in the field of “Speech and Audio Signal Processing”, single (duration 10-15 min) or in groups of two students (15-20 min) or in a group of 20 students and more a written exam (duration 90 min)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slides (for further details see homepage of the lecture)

Courses

Course Nr.	Course name		
18-zo-2070-vl	Speech and Audio Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Henning Puder		Lecture	2

	Course Nr. 18-zo-2070-ue	**Course name** Speech and Audio Signal Processing		
	Instructor Prof. Dr.-Ing. Henning Puder		**Type** Practice	**SWS** 1
	Course Nr. 18-zo-2070-se	**Course name**		
	Instructor Prof. Dr.-Ing. Henning Puder		**Type** Seminar	**SWS** 1

Module name Lab-on-Chip Systems					
Module Nr. 18-bu-2030	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1 Content

- Bioanalytical methods
- Opportunities and fundamental limitations of miniaturization
- Technology of microfluidic systems
- The solid-liquid-interface
- Transport processes
- Biosensors
- Single molecule methods
- PCR-based micro-analytical systems
- Single-cell sequencing
- Flow cytometry
- Optofluidics
- Organ-on-Chip-Technologies
- Advanced microscopy techniques

2 Learning objectives / Learning Outcomes

Students will learn to evaluate and compare conventional and microfluidic bioanalytical methods for laboratory medicine and Point-of-Care applications. They become familiar with the underlying physical principles and scaling laws and learn to analyze the impact of miniaturization quantitatively. The skills acquired in this course will enable the participants to select appropriate techniques, to advance knowledge, and to address technological gaps in the biomedical sciences with the help of microfluidic systems.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Duration: 90 min, Standard Grading System)

Performance will be evaluated based on a written final exam (duration: 90 min.). In case of low enrollment (<11), an oral exam may be offered instead (duration: 30 min.). The mode of the final exam (written or oral) will be announced at the beginning of each semester.

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Biomedical Engineering

7 Grade bonus compliant to §25 (2)

8 References

Lecture notes and reading assignments on Moodle.

Courses

Course Nr. 18-bu-2030-vl	**Course name**		
Instructor Prof. Ph.D. Thomas Peter Burg		**Type** Lecture	**SWS** 2

	Course Nr.	Course name		
	18-bu-2030-ue	Lab-on-Chip Systems		
	Instructor		**Type**	**SWS**
	Prof. Ph.D. Thomas Peter Burg		Practice	2

Module name Technology of Micro- and Precision Engineering					
Module Nr. 18-bu-1010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Ph.D. Thomas Peter Burg		

1	**Content** To explain production processes of parts like: casting, sintering of metal and ceramic parts, injection moulding, metal injection moulding, rapid prototyping, to describe manufacturing processes of parts like: forming processes, compression moulding, shaping, deep-drawing, fine cutting machines, ultrasonic treatment, laser manufacturing, machining by etching, to classify the joining of materials by: welding, bonding, soldering, sticking, to discuss modification of material properties by: tempering, annealing, composite materials.
2	**Learning objectives / Learning Outcomes** Provide insights into the various production and processing methods in micro- and precision engineering and the influence of these methods on the development of devices and components.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script for lecture: Technology of Micro- and Precision Engineering

Courses

	Course Nr. 18-bu-1010-vl	**Course name** Technology of Micro- and Precision Engineering		
	Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Niko Alexander Faul		**Type** Lecture	**SWS** 2
	Course Nr. 18-bu-1010-ue	**Course name** Technology of Micro- and Precision Engineering		
	Instructor Prof. Ph.D. Thomas Peter Burg, M.Sc. Niko Alexander Faul		**Type** Practice	**SWS** 1

Module name Micromechanics and Nanostructured Materials					
Module Nr. 11-01-7070	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr.-Ing. Karsten Durst		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Duration: 15 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-7070-vl	**Course name**		
	Instructor		**Type** Lecture	**SWS** 2

Module name Technology of Nanoobjects					
Module Nr. 11-01-2021	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. rer. nat. Wolfgang Ensinger		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-2021-vl	**Course name**	
	Instructor	**Type** Lecture	**SWS** 2

Module name					
Robust Signal Processing With Biomedical Applications					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2090	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Dr.-Ing. Michael Muma		

1 Content

1. Robust Signal Processing and Learning
   - Measuring robustness
   - Robust estimation of the mean and the variance
   - Robust regression models
   - Robust filtering
   - Robust location and covariance estimation
   - Robust clustering and classification
   - Robust time-series and spectral analysis

2. Biomedical Applications
   - Body-worn sensing of physiological parameters
   - Electrocardiogram (ECG)
   - Photoplethysmogram (PPG)
   - Eye research
   - Intracranial Pressure (ICP)
   - Algorithms for cardiac activity monitoring

The lecture covers fundamental topics and recent developments in robust signal processing. Unlike classical signal processing, which relies strongly on the normal (Gaussian) distribution, robust methods can tolerate impulsive noise, outliers and artifacts that are frequently encountered in biomedical applications. Robust signal processing and biomedical application lectures alternate. Exercises revise the theory and apply robust signal processing algorithms to real world data.

2 Learning objectives / Learning Outcomes

Students understand the basics of robust signal processing and data science and are able to apply them to a variety of problems. They are familiar with various biomedical applications and know the causes of artifacts, outliers and impulsive noise. They can apply algorithms for robust regression, cluster analysis, classification and spectral analysis.

3 Recommended prerequisite for participation

Fundamental knowledge of statistical signal processing

4 Form of examination

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Duration: 180 min, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

A manuscript and lecture slides can be downloaded via Moodle. Further reading

- Zoubir, A. M. and Koivunen, V. and Ollila, E. and Muma, M.: Robust Statistics for Signal Processing. Cambridge University Press, 2018.
- Zoubir, A. M. and Koivunen, V. and Chackchoukh J, and Muma, M. Robust Estimation in Signal Processing: A Tutorial-Style Treatment of Fundamental Concepts. IEEE Signal Proc. Mag. Vol. 29, No. 4, 2012, pp. 61-80.
- Huber, P. J. and Ronchetti, E. M.: Robust Statistics. Wiley Series in Probability and Statistics, 2009.
- Maronna, R. A. and Martin, R. D. and Yohai, V. J.: Robust Statistics: Theory and Methods. Wiley Series in Probability and Statistics, 2006.

Courses

Course Nr.	**Course name**		
18-zo-2090-vl	Robust Signal Processing With Biomedical Applications		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Muma		Lecture	3
Course Nr.	**Course name**		
18-zo-2090-ue	Robust Signal Processing With Biomedical Applications		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Muma		Practice	1

Module name Advanced Light Microscopy					
Module Nr. 11-01-3029	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. rer. nat. Robert Stark		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 1)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 11-01-3029-vl	**Course name**	
	Instructor	**Type** Lecture	**SWS** 2

4.4.2 ASN - Labs and (Project-)Seminars / Problem-oriented Learning

Module name Internship "Medicine Live“					
Module Nr. 18-mt-2190	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Kai Zacharowski		

1 Content

As part of the combined POL seminar / simulation training, students are given the opportunity to work together under supervision on everyday problems in the context of patient care. Problems are evaluated and solution strategies are developed.

- **Anesthesia:** In simulation training, students can practice the procedure of a classic anesthesia on mannequins and deepen previously learned knowledge from lectures and practical courses on airway management and airway devices. Through guided hands-on training, a close link to practice is established and understanding is further deepened.
- **ENT:** Students receive practical insights into procedures of audiological, neurootological and phoniatric diagnostics and are familiarized with the respective device technology. Furthermore, procedures for metrological control of conventional hearing aids are demonstrated and practical exercises are performed. In addition, basic aspects of electrical stimulation of the auditory nerve are clarified by means of practical exercises with cochlear implant systems.

2 Learning objectives / Learning Outcomes

After completing the module, students are able to work out and solve problems and simple issues independently in context. The students receive an overview of the equipment technology used in the specialties of anesthesia and ENT/phoniatrics. In the practical part, manual skills are trained and the use of various diagnostic devices is practiced. This provides a better understanding of medical activities, which facilitates communication with users of medical technology equipment in later professional life.

3 Recommended prerequisite for participation

Competencies from the “Anesthesia I & II” modules.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Presentation, Duration: 20 min, Pass/Fail Grading System)

The oral examination takes the form of a presentation during the internship. As a rule, there is one presentation per content area (anesthesia and ENT).

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Presentation, Weighting: 100 %)

6 Usability of this module

M.Sc. Biomedical Engineering

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr. 18-mt-2190-pr	**Course name** Internship "Medicine Live“		
Instructor Prof. Dr. Kai Zacharowski		**Type** Internship	**SWS** 2

Module name Biomedical Microwave-Theranostics: Sensors and Applicators					
Module Nr. 18-jk-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Rolf Jakoby		

1	**Content** Application of biomedical sensors based on electromagnetic waves and their advantages. Fundamentals of microfluidics as tool for microwave-based sensing of fluids, electroporation; diagnostic and therapeutic applications of microwaves, microwave applicators for imaging, diagnosis and treatment; computer-based methods for field propagation in biological tissues and those applications. Work on a current scientific issue with individual supervision.
2	**Learning objectives / Learning Outcomes** Students understand the physical basics of microwave-based sensors for biomedicine. They are able to derive the advantages of the use of microwaves compared to other technologies. They know fields of applications concerning microwave-based diagnostics and treatments and can handle the physical context of used applicators. Practical examples lead to strenghtening these abilities. Students know computer-based simulation tools for the design and characterization of microwave applicators. They gained experience while working on a practical example with such a simulation software. Students are able to solve manageable scientific problems within the frame of a coordinated project work. They can summarize the current state of the art and write a scientific paper about it. The results are presented and discussed in a final presentation.
3	**Recommended prerequisite for participation** Biomedical Microwave Engineering
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (10 minutes) and an oral examination (30 minutes).
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Necessary publications and recommended literature as well as simulation software tools are provided.

Courses

	Course Nr.	**Course name**		
	18-jk-2120-pj	Biomedical Microwave-Theranostics: Sensors and Applicators		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Rolf Jakoby, Dr.-Ing. Martin Schüßler		Project Seminar	3

Module name					
Product Development Methodology II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-1025	5 CP	150 h	105 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organization of development. Work in a project team and organize the development process independently.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-ho-1025-pj	Product Development Methodology II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

Module name					
Product Development Methodology III					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-bu-2125	5 CP	150 h	105 h	1	WiSe
Language			**Module owner**		
German			Prof. Ph.D. Thomas Peter Burg		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organisation of development. Work in a project team and organize the development process independendly.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as bills of materials, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC, MSc WI-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-bu-2125-pj	Product Development Methodology III		
Instructor		**Type**	**SWS**
Prof. Ph.D. Thomas Peter Burg, Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik		Project Seminar	3

Module name					
Product Development Methodology IV					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kh-2125	5 CP	150 h	105 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr.-Ing. Khanh Quoc Tran		

1	**Content** Practical experiences by using methodical procedures in the development of technical products. In addition teamwork, verbal and written representation of results and the organization of development. Work in a project team and organize the development process independently.
2	**Learning objectives / Learning Outcomes** Applying the development methodology to a specific development project in a team. To do this, students can create a schedule, can analyze the state of the art, can compose a list of requirements, can abstract the task, can work out the sub-problems, can seek solutions with different methods, can work out optimal solutions using valuation methods, can set up a final concept, can derive the parameters needed by computation and modeling, can create the production documentation with all necessary documents such as part lists, technical drawings and circuit diagrams, can build up and investigate a laboratory prototype and can reflect their development in retrospect.
3	**Recommended prerequisite for participation** Product Development Methodology I
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Script: Development Methodology (PEM)

Courses

Course Nr.	Course name		
18-kh-2125-pj	Product Development Methodology IV		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Khanh Quoc Tran, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr. Mario Kupnik, Prof. Ph.D. Thomas Peter Burg		Project Seminar	3

Module name					
Electromechanical Systems Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kn-2090	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. Mario Kupnik		

1	**Content** Electromechanical sensors, drives and actuators, electronic signal processing mechanisms, systems from actuators, sensors and electronic signal processing mechanism.
2	**Learning objectives / Learning Outcomes** Elaborating concrete examples of electromechanical systems, which are explained within the lecture EMS I+II. The Analyzing of these examples is needed to explain the mode of operation and to gather characteristic values. On this students are able to explain the derivative of proposals for the solution. The aim of the 6 laboratory experiments is to get to know the mode of operation of the electro- mechanical systems. The experimental analysis of the characteristic values leads to the derivation of proposed solutions.
3	**Recommended prerequisite for participation** Bachelor ETiT
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc WI-ETiT, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Laboratory script in Electromechanical Systems

Courses

Course Nr. 18-kn-2090-pr	**Course name** Electomechanical Systems Lab		
Instructor Prof. Dr. Mario Kupnik		**Type** Internship	**SWS** 3
Course Nr. 18-kn-2090-ev	**Course name** Electomechanical Systems Lab - Introduction		
Instructor Prof. Dr. Mario Kupnik		**Type** Introductory Course	**SWS** 0

Module name					
Advanced Topics in Statistical Signal Processing					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2040	8 CP	240 h	180 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

This course extends the signal processing fundamentals taught in DSP towards advanced topics that are the subject of current research. It is aimed at those with an interest in signal processing and a desire to extend their knowledge of signal processing theory in preparation for future project work (e.g. Diplomarbeit) and their working careers. This course consists of a series of five lectures followed by a supervised research seminar during two months approximately. The final evaluation includes students seminar presentations and a final exam.

The main topics of the Seminar are:

- Estimation Theory
- Detection Theory
- Robust Estimation Theory
- Seminar projects: e.g. Microphone array beamforming, Geolocation and Tracking, Radar Imaging, Ultrasound Imaging, Acoustic source localization, Number of sources detection.

2 Learning objectives / Learning Outcomes

Students obtain advanced knowledge in signal processing based on the fundamentals taught in DSP and ETiT 4. They will study advanced topics in statistical signal processing that are subject to current research. The acquired skills will be useful for their future research projects and professional careers.

3 Recommended prerequisite for participation

DSP, general interest in signal processing is desirable.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc iCE, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

- L. L. Scharf, Statistical Signal Processing: Detection, Estimation, and Time Series Analysis (New York: Addison-Wesley Publishing Co., 1990).
- S. M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory (Book 1), Detection Theory (Book 2).
- R. A. Maronna, D. R. Martin, V. J. Yohai, Robust Statistics: Theory and Methods, 2006.

Courses

Course Nr.	Course name		
18-zo-2040-se	Advanced Topics in Statistical Signal Processing		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Seminar	4

Module name					
Computational Modeling for the IGEM Competition					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-kp-2100	4 CP	120 h	90 h	1	WiSe/SoSe
Language			**Module owner**		
English			Prof. Dr. techn. Heinz Köppl		

1 Content

The International Genetically Engineered Machine (IGEM) competition is a yearly international student competition in the domain of synthetic biology, initiated and hosted by the Massachusetts Institute of Technology (MIT), USA since 2004. In the past years teams from TU Darmstadt participated and were very successfully in the competition. This seminar provides training for students and prospective IGEM team members in the domain of computational modeling of biomolecular circuits. The seminar aims at computationally inclined students from all background, but in particular from electrical engineering, computer science, physics and mathematics. Seminar participants that are interested to become IGEM team members could later team up with biologists and biochemists for the 2017 IGEM project of TU Darmstadt and be responsible for the computational modeling part of the project.
The seminar will cover basic modeling approaches but will focus on discussing and presenting recent high-impact synthetic biology research results and past IGEM projects in the domain of computational modeling.

2 Learning objectives / Learning Outcomes

Students that successfully passed that seminar should be able to perform practical modeling of biomolecular circuits that are based on transcriptional and translational control mechanism of gene expression as used in synthetic biology. This relies on the understanding of the following topics:

- Differential equation models of biomolecular processes
- Markov chain models of biomolecular processes
- Use of computational tools for the composition of genetic parts into circuits
- Calibration methods of computational models from experimental measurement
- Use of bioinformatics and database tools to select well-characterized genetic parts

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

BSc etit, MSc etit

7 Grade bonus compliant to §25 (2)

8 References

Courses

Course Nr.	Course name		
18-kp-2100-se	Computational Modeling for the IGEM Competition		
Instructor		**Type**	**SWS**
Prof. Dr. techn. Heinz Köppl		Seminar	2

Module name					
Signal Detection and Parameter Estimation					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-zo-2050	8 CP	240 h	180 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Abdelhak Zoubir		

1 Content

Signal detection and parameter estimation are fundamental signal processing tasks. In fact, they appear in many common engineering operations under a variety of names. In this course, the theory behind detection and estimation will be presented, allowing a better understanding of how (and why) to design "good" detection and estimation schemes.
These lectures will cover: Fundamentals
Detection Theory Hypothesis Testing Bayesian Tests
Ideal Observer Tests
Neyman-Pearson Tests
Receiver Operating Characteristics
Uniformly Most Powerful Tests
The Matched Filter Estimation Theory Types of Estimators
Maxmimum Likelihood Estimators
Sufficiency and the Fisher-Neyman/Factorisation Criterion
Unbiasedness and Minimum variance
Fisher Information and the CRB
Asymptotic properties of the MLE

2 Learning objectives / Learning Outcomes

Students gain deeper knowledge in signal processing based on the fundamentals taught in DSP and EtiT 4. Thexy will study advanced topics of statistical signal processing in the area of detection and estimation.
In a sequence of 4 lectures, the basics and important concepts of detection and estimation theory will be taught. These will be studied in dept by implementation of the methods in MATLAB for practical examples. In sequel, students will perform an independent literature research, i.e. choosing an original work in detection and estimation theory which they will illustrate in a final presentation.
This will support the students with the ability to work themselves into a topic based on literature research and to adequately present their knowledge. This is especially expected in the scope of the students' future research projects or in their professional carreer.

3 Recommended prerequisite for participation

DSP, general interest in signal processing

4 Form of examination

Module Final Examination:
- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:
- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT,MSc iST, MSc iCE, Wi-ETiT

7 Grade bonus compliant to §25 (2)

8 References

- Lecture slides
- Jerry D. Gibson and James L. Melsa. Introduction to Nonparametric Detection with Applications. IEEE Press, 1996.
- S. Kassam. Signal Detection in Non-Gaussian Noise. Springer Verlag, 1988.
- S. Kay. Fundamentals of Statistical Signal Processing: Estimation Theory. Prentice Hall, 1993.
- S. Kay. Fundamentals of Statistical Signal Processing: Detection Theory. Prentice Hall, 1998.
- E. L. Lehmann. Testing Statistical Hypotheses. Springer Verlag, 2nd edition, 1997.
- E. L. Lehmann and George Casella. Theory of Point Estimation. Springer Verlag, 2nd edition, 1999.
- Leon-Garcia. Probability and Random Processes for Electrical Engineering. Addison Wesley, 2nd edition, 1994.
- P. Peebles. Probability, Random Variables, and Random Signal Principles. McGraw-Hill, 3rd edition, 1993.
- H. Vincent Poor. An Introduction to Signal Detection and Estimation. Springer Verlag, 2nd edition, 1994.
- Louis L. Scharf. Statistical Signal Processing: Detection, Estimation, and Time Series Analysis. Pearson Education POD, 2002.
- Harry L. Van Trees. Detection, Estimation, and Modulation Theory, volume I,II,III,IV. John Wiley & Sons, 2003.
- A. M. Zoubir and D. R. Iskander. Bootstrap Techniques for Signal Processing. Cambridge University Press, May 2004.

Courses

Course Nr.	**Course name**		
18-zo-2050-se	Signal Detection and Parameter Estimation		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Abdelhak Zoubir		Seminar	4

5 Additional Optional Subarea

5.1 Optional Subarea Ethics and Technology Assessment (ET)

5.1.1 ET - Lectures

Module name Introduction to Ethics: The Example of Medical Ethics						
Module Nr. 18-mt-2200	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe	
Language German			**Module owner** Prof. Dr. Christof Carl Markus Mandry			
1	**Content** In exploring basic questions of medical ethics, the lecture provides an introduction to ethical thinking and the theories and reasoning of ethics. At the same time, it imparts basic knowledge about central and selected current discussions in medical ethics and healthcare ethics. Different Levels will be dealt with: What are the sets od values comprised in our notions of health and illness? What are the necessary requirements for decisions to be ethically good and correct? How are courses of action at the beginning and at the end of life to be evaluated? Is health to be regarded as an “asset” that can be "distributed" through public systems, and what criteria of justice do healthcare systems have to meet?					
2	**Learning objectives / Learning Outcomes** Students know basic terms of ethics, like norm, responsibility, duty, ought, and (human) rights, as well as central classifications of ethics into metaethics, ought ethics, aspiration ethics, and domain ethics. They are familiar with different approaches to ethics and the justification of norms (deontological / teleological, virtue ethical approaches) and their respective theoretical prerequisites as well as strengths and weaknesses. Also, they are familiar with medical ethics being specific ethics with typical approaches like the Beauchamp/Childress principles model. Students have a basic understanding of fundamental conflicts in medical ethical decision making, for example regarding treatment at the beginning and the end of life and are able to analyze exemplary cases in a structured manner and make well-founded assessments. They know central legal regulations of selected clinical contexts (such as living wills or organ donation) and are familiar with the corresponding ethical discussions. They are familiar with basic social-ethical approaches like Rawls’ theory of justice and understand their relevance to healthcare. They are able to identify and classify institutional-ethical issues of healthcare.					
3	**Recommended prerequisite for participation**					
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Duration: 60 min, Standard Grading System) Module exam usually is a written exam (duration: 60 minutes) or an oral exam (duration: 15-20 minutes). The examination method will be announced at the start of the lecture, or one week after the end of the exam registration period (during terms where no courses are offered).					
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)					
6	**Usability of this module** *M.Sc. Biomedical Engineering*					

7	**Grade bonus compliant to §25 (2)**			
8	**References**			
Courses				
	Course Nr. 18-mt-2200-vl	**Course name** Introduction to Ethics: The Example of Medical Ethics		
	Instructor Prof. Dr. Christof Carl Markus Mandry		**Type** Lecture	**SWS** 2

Module name Ethics and Application					
Module Nr. 02-21-2027	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. phil. Petra Gehring		
1	**Content**				
2	**Learning objectives / Learning Outcomes**				
3	**Recommended prerequisite for participation**				
4	**Form of examination** Module Eccompanying Examination: • [02-11-2027-ku] (Study Achievement, Written/Oral Examination, BWS b/nb)				
5	**Grading** Module Eccompanying Examination: • [02-11-2027-ku] (Study Achievement, Written/Oral Examination, Weighting: 100 %)				
6	**Usability of this module**				
7	**Grade bonus compliant to §25 (2)**				
8	**References**				
Courses					
	Course Nr. 02-11-2027-ku	**Course name** Ethics and their Application			
	Instructor		**Type** Course	**SWS** 2	

Module name Ethics and Technology Assessement					
Module Nr. 02-21-2025	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. phil. Petra Gehring		

1	**Content**
2	**Learning objectives / Learning Outcomes**
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [02-11-2025-ku] (Study Achievement, Written/Oral Examination, BWS b/nb)
5	**Grading** Module Eccompanying Examination: • [02-11-2025-ku] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 02-11-2025-ku	**Course name** Ethics and Evaluation of Technology		
	Instructor		**Type** Course	**SWS** 2

Module name Ethics in Natural Language Processing					
Module Nr. 20-00-1061	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** Machine Learning and Natural Language technologies are integrated in more and more aspects of our life. Therefore, the decisions we make about our methods and data are closely tied up with their impact on our world and society. In this course, we present real-world, state-of-the-art applications of natural language processing and their associated ethical questions and consequences. We also discuss philosophical foundations of ethics in research. Core topics of this course: - Philosophical foundations: what is ethics, history, medical and psychological experiments, ethical decision making. - Misrepresentation and bias: algorithms to identify biases in models and data and adversarial approaches to debiasing. - Privacy: algorithms for demographic inference, personality profiling, and anonymization of demographic and personal traits. - Civility in communication: techniques to monitor trolling, hate speech, abusive language, cyberbullying, toxic comments. - Democracy and the language of manipulation: approaches to identify propaganda and manipulation in news, to identify fake news, political framing. - NLP for Social Good: Low-resource NLP, applications for disaster response and monitoring diseases, medical applications, psychological counseling, interfaces for accessibility.
2	**Learning objectives / Learning Outcomes** After completion of the lecture, the students are able to - explain philosophical and practical aspects of ethics - show the limits and limitations of machine learning models - Use techniques to identify and control bias and unfairness in models and data - Demonstrate and quantify the impact of influencing opinions in data processing and news - Identify hate speech and online abuse and develop countermeasures
3	**Recommended prerequisite for participation** Basic knowledge of algorithms, data structure and programming
4	**Form of examination** Module Eccompanying Examination: • [20-00-1061-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1061-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**
Courses	

	Course Nr.	Course name		
	20-00-1061-iv	Ethics in Natural Language Processing		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Integrated Course	4

Module name Current Issues in Medical Ethics					
Module Nr. 18-mt-2210	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. Christof Carl Markus Mandry		

1	**Content** This course deals in depth with current issues in medical ethics. These can either de related to clinical ethics (ethical decisions in medicine), such as organ removal and organ transplantation, change of therapeutic objectives, terminal care, etc. Or the issues are related to research ethics (for example research on individuals without capability to consent) or to the development of new treatments, for example in biomedicine, prosthetics, enhancement, etc. Key points are methodological questions of applied ethics, such as consideration of ethical and legal aspects, as well as questions of justification.
2	**Learning objectives / Learning Outcomes** Students will have acquired higher level skills to theoretically and methodologically reflect, analyze and reason within the scientific area of applied medical ethics. They are able to relate questions of justification and practicability to one another, whilst considering different objective and disciplinary perspectives. They are able to theoretically and methodologicalleyanalyze current topics in medical ethics and, at the same time, to discern different levels (persons affected, institutional and social contexts), and to combine ethical perspectives (such as perspectives of individual, social, and legal ethics). They master different ethical approaches, have an understanding of their prerequisites and scopes, and can apply them in a way suitable to the respective context. Students have a deepened understanding of the subject and are capable of ethical assessment. They are able to work on specific topics and questions, and to present their results in a comprehensible way.
3	**Recommended prerequisite for participation** A basic understanding of ethics and / or medical ethics is desirable.
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) The examination method will be announced at the start of the first lesson. Possible forms are either giving a keynote presentation (duration: 20 min.) followed by a discussion or writing a protocol.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 18-mt-2210-se	**Course name** Current Issues in Medical Ethics	
Instructor Prof. Dr. Christof Carl Markus Mandry	**Type** Seminar	**SWS** 2

Module name					
Anthropological and Ethical Issues of Digitization					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-mt-2220	3 CP	90 h	60 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. Christof Carl Markus Mandry		

1	**Content** In this seminar, we will analyze current and developing applications of digitization and AI in different areas of life, and also discuss them with regard to the perspectives of philosophy of technology, anthropology and ethics. In doing so, we will deal with fundamental questions such as the relationship between man and technology, the autonomy of autonomous systems, or the meaning of “responsibility”, "action" or "intelligence" in the context of digitality and AI. Also, the seminar deals with the generic anthropological and ethical analysis and evaluation of particular scopes of application, in which digitization or AI play a key role, such as healthcare (health apps, big data mining, care robots), transportation (autonomous driving) etc., whilst applying interdisciplinary approaches like ethical design, algorithmic ethics, and privacy.
2	**Learning objectives / Learning Outcomes** Students are familiar with fundamental concepts of digitization and AI, and are able to take position in related discussions, for example regarding subject status, intelligence and capability of action, as well as the moral capacity of digital systems and systems involving AI. They are familiar with theories of technological development, like the theory of singularity, and the respective anthropological and ethical challenge involved. They are familiar with the approaches of philosophy and ethics of technology, for example digital design, as well as with critical stances regarding data security / privacy, and are able to apply them in certain scopes and with regards to particular developments. Students are able to analyze and present exemplary applications and developments regarding their technological, social and ethical aspects, and to profoundly discuss them with regard to their ethical and anthropological issues. In doing so, they are able to apply different approaches of ethics of technology and social ethics.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (20 minutes), moderation or oral examination.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 18-mt-2220-se	**Course name** Anthropological and Ethical Issues of Digitization	
	Instructor Prof. Dr. Christof Carl Markus Mandry	**Type** Seminar	**SWS** 2

5.2 Optional Subarea Medical Data Science (MD)

5.2.1 MD - Lectures

Module name Information Management					
Module Nr. 20-00-0015	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. phil. nat. Marc Fischlin		

1 Content

Information Management Concepts:
Information systems concepts
Information storage/retrieval, searching, browsing, navigational vs. declarative access
Quality issues: consistency, scalability, availability, reliability
Data Modeling:
Conceptual data models (ER/UML structure diagr.)
Conceptual design
Operational models (relational model)
Mapping from conceptual to operational model
Relational Model:
Operators
Relational algebra
Relational calculus
Implications on query languages derived from RA and RC
Design theory, normalization
Query Languages
SQL (in detail)
QBE, Xpath, rdf (high level)
Storage media
RAID, SSDs
Buffering, caching
Implementation of relational operators:
Implementation algorithms
Cost functions
Query optimization:
Heuristic query optimization
Cost based query optimization
Transaction processing (concurrency control and recovery):
Flat transactions
Concurrency control, correctness criteria: serializability, recoverability, ACA, strictness
Isolation levels
Lock-based schedulers, 2PL
Multiversion concurrency control
Optimistic schedulers
Logging
Checkpointing
Recovery/restart
New trends in data management
Main memory databases
Column stores
NoSQL

2 Learning objectives / Learning Outcomes

	After successfully attending the course, students are familiar with the fundamental concepts of information management. They understand the techniques for realizing information management systems and can apply the models, algorithms and languages to independently use and (partially) implement information management systems that fulfill the given requirements. They are able to evaluate such systens in a number of quality metrics.
3	**Recommended prerequisite for participation** Recommended: Participation of lecture „Funktionale und Objektorientierte Programmierkonzepte“ and „Algorithmen und Datenstrukturen“, respective according knowledge.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0015-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0015-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik B.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Will be updated regularly, an example might be: Haerder, Rahm, “Datenbanksysteme - Konzepte und Techniken der Implementierung”, Springer 1999 Elmasri, R., Navathe, S. B.: Fundamentals of Database Systems, 3rd. ed., Redwood City, CA: Benjamin/Cummings Ullman, J. D.: Principles of Database and Knowledge-Base Systems, Vol. 1 Computer Science

Courses

	Course Nr.	**Course name**		
	20-00-0015-iv	Information Management		
	Instructor		**Type** Integrated Course	**SWS** 3

Module name					
Computer Security					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0018	5 CP	150 h	105 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. phil. nat. Marc Fischlin		

1	**Content** Part I: Cryptography - Background in Mathematics for cryptography - Security objectives: Confidentiality, Integrity, Authenticity - Symmetric and Asymmetric Cryptography - Hash functions and digital signatures - Protocols for key distribution Part II: IT-Security and Dependability - Basic concepts of IT security - Authentication and biometrics - Access control models and mechanisms - Basic concepts of network security - Basic concepts of software security - Dependable systems: error tolerance, redundancy, availability
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with the basic concepts, methods and models in the areas of cryptography and computer security. They understand the most important methods that allow to secure software and hardware systems against attackers and are able to apply this knowledge to concrete application scenarios.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-0018-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0018-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik B.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik B.Sc. Informationssystemtechnik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - J. Buchmann, Einführung in die Kryptographie, Springer-Verlag, 2010 - C. Eckert, IT-Sicherheit, Oldenbourg Verlag, 2013 - M. Bishop, Computer Security: Art and Science, Addison Wesley, 2004
Courses	

	Course Nr.	Course name		
	20-00-0018-iv	Computer Security		
	Instructor		**Type**	**SWS**
			Integrated Course	3

Module name Introduction to Artificial Intelligence					
Module Nr. 20-00-1058	**Credit Points** 5 CP	**Workload** 150 h	**Self study** 105 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** Artificial Intelligence (AI) is concerned with algorithms for solving problems, whose solution is generally assumed to require intelligence. While research in the early days was oriented on results about human thinking, the field has since developed towards solutions that try to exploit the strengths of the computer. In the course of this lecture we will give a brief survey over key topics of this core discipline of computer science, with a particular focus on the topics search, planning, learning, and reasoning. Historical and philosophical foundations will also be considered. - Foundations - Introduction, History of AI (RN chapter 1) - Intelligent Agents (RN chapter 2) - Search - Uninformed Search (RN chapters 3.1 - 3.4) - Heuristic Search (RN chapters 3.5, 3.6) - Local Search (RN chapter 4) - Constraint Satisfaction Problems (RN chapter 6) - Games: Adversarial Search (RN chapter 5) - Planning - Planning in State Space (RN chapter 10) - Planning in Plan Space (RN chapter 11) - Decisions under Uncertainty - Uncertainty and Probabilities (RN chapter 13) - Bayesian Networks (RN chapter 14) - Decision Making (RN chapter 16) - Machine Learning - Neural Networks (RN chapters 18.1,18.2,18.7) - Reinforcement Learning (RN chapter 21) - Philosophical Foundations
2	**Learning objectives / Learning Outcomes** After a successful completion of this course, students are in a position to - understand and explain fundemental techniques of artificial intelligence - participate in a discussion about the possibility of an artificial intelligence with well-founded arguments - critically judge new developments in this area
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-1058-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1058-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**

8	**References**

Courses				
	Course Nr. 20-00-1058-iv	**Course name** Intruduction to Artificial Intelligence		
	Instructor Prof. Dr. techn. Johannes Fürnkranz		**Type** Integrated Course	**SWS** 3

Module name Medical Data Science					
Module Nr. 18-mt-2230	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 45 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner**		

1 Content

Students will attend a regular series of lectures and seminars (colloquium) in which they obtain extensive information about theory as well as practical experiences from the fields of medical informatics and medical data science. In these regular talks, members of the Medical Informatics Group, staff from the data integration centre as well as national and international speakers present timely and relevant topics from the field. The schedule will be provided in time.

Topics:

- Set up and establishment of patient registries
- Anonymization of public health data
- Consent and data protection
- Overview of research infrastructure in medical informatics and related disciplines
- Development of software solutions for applications and application management

2 Learning objectives / Learning Outcomes

Students shall:

- familiarize themselves with timely topics from the field of medical informatics
- know methodologies in medical informatics and their applications
- understand data exploiration and usage of medical data
- understand inderdisciplinary research approaches
- get a possibility for networking

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Standard Grading System)

The type of examination will be announced in the first lecture. Possible types include reports or protocols.

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Written Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Biomedical Engineering

7 Grade bonus compliant to §25 (2)

8 References

Recent publications of the speakers (will be announced)

Courses

Course Nr. 18-mt-2230-ko	**Course name** Medical Data Science		
Instructor		**Type** Colloquy	**SWS** 1

Module name					
Advanced Data Management Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1039	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** This is an advanced course about the design of modern data management systems which has a heavy emphasis on system design and internals. Sample topics include modern hardware for data management, main memory optimisations, parallel and approximate query processing, etc. The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.
2	**Learning objectives / Learning Outcomes** Upon successful completion of this course, the student should be able to: - Understand state-of-the-art techniques for modern data management systems - Discuss design decision of modern data management systems with emphasis on constructive improvements - Implement advanced data management techniques and provide experimental evidence for design decisions
3	**Recommended prerequisite for participation** Solid Programming skills in C and C++ Scalable Data Management (20-00-1017-iv) Information Management (20-00-0015-iv)
4	**Form of examination** Module Eccompanying Examination: • [20-00-1039-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1039-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr.	**Course name**		
	20-00-1039-iv	Advanced Data Management Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Integrated Course	4

Module name					
Data Mining and Machine Learning					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0052	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German and English			Prof. Dr. techn. Johannes Fürnkranz		

1 Content

With the rapid development of information technology bigger and bigger amounts of data are available. These often contain implicit knowledge, which, if it were known, could have significant commercial or scientific value. Data Mining is a research area that is concerned with the search for potentially useful knowledge in large data sets, and machine learning is one of the key techniques in this area.
This course offers an introduction into the area of machine learning from the angle of data mining. Different techniques from various paradigms of machine learning will be introduced with exemplary applications. To operationalize this knowledge, a practical part of the course is concerned with the use of data mining tools in applications.
- Introduction (Foundation, Learning problems, Concepts, Examples, Representation)
- Rule Learning
- Learning of indivicual rules (generalization vs. specialization, structured hypothesis spaces, version spaces)
- Learning of rule sets (covering strategy, evaluation measures for rules, pruning, multi-class problems)
- Evaluation and cost-sensitive Learning (Accuracy, X-Val, ROC Curves, Cost-Sensitive Learning)
- Instance-Based Learning (kNN, IBL, NEAR, RISE)
- Decision Tree Learning (ID3, C4.5, etc.)
- Ensemble Methods (Bias/Variance, Bagging, Randomization, Boosting, Stacking, ECOCs)
- Pre-Processing (Feature Subset Selection, Discretization, Sampling, Data Cleaning)
- Clustering and Learning of Association Rules (Apriori)"

2 Learning objectives / Learning Outcomes

After a successful completion of this course, students are in a position to
- understand and explain fundemental techniques of data mining and machine learning
- apply practical data mining systems and understand their strengths and limitations
- critically judge new developments in this area

3 Recommended prerequisite for participation

4 Form of examination

Module Eccompanying Examination:
- [20-00-0052-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:
- [20-00-0052-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

“B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
Kann im Rahmen fachübergreifender Angebote auch in anderen Studiengängen verwendet werden.”

7 Grade bonus compliant to §25 (2)

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Mitchell: Machine Learning, McGraw-Hill, 1997 - Ian H. Witten and Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan-Kaufmann, 1999

Courses

	Course Nr.	**Course name**		
	20-00-0052-iv	Machine Learning and Data Mining		
	Instructor		**Type** Integrated Course	**SWS** 4

Module name					
Deep Learning: Architectures & Methods					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1034	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** * Review of machine learning background * Deep Feedforward Networks * Regularization for Deep Learning * Optimization for Training Deep Models * Convolutional Networks * Sequence Modeling: Recurrent and Recursive Nets * Linear Factor Models * Autoencoders * Representation Learning * Structured Probabilistic Models for Deep Learning * Monte Carlo Methods * Approximate Inference * Deep Generative Models * Deep Reinforcement Learning * Deep Learning in Vision * Deep Learning in NLP
2	**Learning objectives / Learning Outcomes** This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.
3	**Recommended prerequisite for participation** 20-00-0358-iv Statistical Machine Learning 20-00-0052-iv Data Mining and Machine Learning
4	**Form of examination** Module Eccompanying Examination: • [20-00-1034-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1034-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

Courses

	Course Nr.	Course name		
	20-00-1034-iv	Deep Learning: Architectures & Methods		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Integrated Course	4

Module name Deep Learning for Natural Language Processing					
Module Nr. 20-00-0947	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. phil. Iryna Gurevych		

1	**Content** The lecture provides an introduction to the foundational concepts of deep learning and their application to problems in the area of natural language processing (NLP) Main content: - foundations of deep learning (e.g. feed-forward networks, hidden layers, backpropagation, activation functions, loss functions) - word embeddings: theory, different approaches and models, application as features for machine learning - different architectures of neuronal networks (e.g. recurrent NN, recursive NN, convolutional NN) and their application for groups of NLP problems such as document classification (e.g. spam detection), sequence labeling (e.g. POS-tagging, Named Entity Recognition) and more complex structure prediction (e.g. Chunking, Parsing, Semantic Role Labeling)
2	**Learning objectives / Learning Outcomes** After completion of the lecture, the students are able to - explain the basic concepts of neural networks and deep learning. - explain the concept of word embeddings, train word embeddings and use them for solving NLP problems. - understand and describe neural network architectures that are used to tackle classical NLP problems such as classification, sequence prediction, structure prediction. - implement neural networks for NLP problems using existing libraries in Python.
3	**Recommended prerequisite for participation** Basic knowledge of mathematics and programming
4	**Form of examination** Module Eccompanying Examination: • [20-00-0947-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0947-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 20-00-0947-iv	**Course name** Deep Learning for Natural Language Processing	
	Instructor Prof. Dr. phil. Iryna Gurevych	**Type** Integrated Course	**SWS** 4

Module name					
Foundations of Language Technology					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0546	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German			Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** This lecture provides an introduction into the fundamental perspectives, problems, methods, and techniques of text technology and natural language processing using the example of the Python programming language. Key topics: - Natural language processing (NLP) - Tokenization - Segmentation - Part-of-speech tagging - Corpora - Statistical analysis - Machine Learning - Categorization and classification - Information extraction - Introduction to Python - Data structures - Structured programming - Working with files - Usage of libraries - NLTK library The course is based on the Python programming language together with an open-source library called the Natural Language Toolkit (NLTK). NLTK allows explorative and problem-solving learning of theoretical concepts without the requirement of extensive programming knowledge.
2	**Learning objectives / Learning Outcomes** After attending this course, students are in a position to - define the fundamental terminology of the language technology field, - specify and explain the central questions and challenges of this field, - explicate and implement simple Python programs, - transfer the learned techniques and methods to practical application scenarios of text understanding, as well as - critically assess their merits and limitations.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-0546-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0546-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Steven Bird, Ewan Klein, Edward Loper: Natural Language Processing with Python, O'Reilly, 2009. ISBN: 978-0596516499. http://www.nltk.org/book/

Courses

	Course Nr.	**Course name**		
	20-00-0546-iv			
	Instructor		**Type**	**SWS**
	Prof. Dr. phil. Iryna Gurevych		Integrated Course	4

Module name IT Security					
Module Nr. 20-00-0219	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Content** Selected concepts of IT-Security (cryptography, security models, authentication, access control, security in networks; trusted computing, security engineering, privacy, web and browser security, information security management, IT forensic, cloud computing)
2	**Learning objectives / Learning Outcomes** After successful participation in the course, students are versant in common mechanisms and protocols to increase security in modern it-systems. Students have broad knowledge of it-security, data protection and privacy on the Internet. Students are familiar with modern information technology security concepts from the field of cryptography, identity management, web, browser and network security. Students are able to identify attack vectors in it-systems and develop countermeasures.
3	**Recommended prerequisite for participation** Participation of lecture Trusted Systems
4	**Form of examination** Module Eccompanying Examination: • [20-00-0219-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0219-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** * C. Eckert: IT-Sicherheit, 3. Auflage, Oldenbourg Verlag, 2004 * J. Buchmann, Einführung in die Kryptographie, 2.erw. Auflage, Springer Verlag, 2001 * E. D. Zwicky, S. Cooper, B. Chapman: Building Internet Firewalls, 2. Auflage, O'Reilly, 2000 * B. Schneier, Secrets & Lies: IT-Sicherheit in einer vernetzten Welt, dpunkt Verlag, 2000 * W. Rankl und W. Effing: Handbuch der Chipkarten, Carl Hanser Verlag, 1999 * S. Garfinkel und G. Spafford: Practical Unix & Internet Security, O'Reilly & Associates
Courses	

	Course Nr. 20-00-0219-iv	Course name IT Security		
	Instructor		Type Integrated Course	SWS 4

Module name					
Communication Networks I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-1010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

In this class the technologies that make today's communication networks work are introduced and discussed.

This lecture covers basic knowledge about communication networks and discusses in detail the physical layer, the data link layer, the network layer and parts of the transport layer.

The physical layer, which is responsible for an adequate transmission across a channel, is discussed briefly. Next, error control, flow control and medium access mechanisms of the data link layer are presented. Then the network layer is discussed. It comprises mainly routing and congestion control algorithms. After that basic functionalities of the transport layer are discussed. This includes UDP and TCP. The Internet is thoroughly studied throughout the class.

Detailed Topics are:

- ISO-OSI and TCP/IP layer models
- Tasks and properties of the physical layer
- Physical layer coding techniques
- Services and protocols of the data link layer
- Flow control (sliding window)
- Applications: LAN, MAN, High-Speed LAN, WAN
- Services of the network layer
- Routing algorithms
- Broadcast and Multicast routing
- Congestion Control
- Addressing
- Internet protocol (IP)
- Internetworking
- Mobile networking
- Services and protocols of the transport layer
- TCP, UDP

2 Learning objectives / Learning Outcomes

This lecture teaches about basic functionalities, services, protocols, algorithms and standards of network communication systems. Competencies aquired are basic knowledge about the lower four ISO-OSI layers: physical layer, datalink layer, network layer and transport layer; Furthermore, basic knowledge about communication networks is taught. Attendants will learn about the functionality of today's network technologies and the Internet.

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

Wi-CS, Wi-ETiT, BSc CS, BSc ETiT, BSc iST

7	**Grade bonus compliant to §25 (2)** A bonus of 0.3 or 0.7 can be obtained. For 0.3 bonus: 7 out of 9 exercises are to be solved to the best of your knowledge. That is, every question needs to be answered. However, not every question needs to be answered correctly. Additionally, at least one wiki article or applet concerning a topic of the lecture has to be provided (written). For the 0.7 bonus: Additionally, present one exercise and write at least three wiki articles, or write at least 5 wiki articles. An oral exam ("Fachgespräch") is mandatory in order to receive the bonus. The bonus can only be applied if the exam grade is 4.0 or better.
8	**References** • Andrew S. Tanenbaum: Computer Networks, 5th Edition, Prentice Hall, 2010 • Andrew S. Tanenbaum: Computernetzwerke, 3. Auflage, Prentice Hall, 1998 • Larry L. Peterson, Bruce S. Davie: Computer Networks: A System Approach, 2nd Edition, Morgan Kaufmann Publishers, 1999 • Larry L. Peterson, Bruce S. Davie: Computernetze, Ein modernes Lehrbuch, 2. Auflage, Dpunkt Verlag, 2000 • James F. Kurose, Keith W. Ross: Computer Networking: A Top-Down Approach Featuring the Internet, 2nd Edition, Addison Wesley-Longman, 2002 • Jean Walrand: Communication Networks: A First Course, 2nd Edition, McGraw-Hill, 1998

Courses

Course Nr. 18-sm-1010-vl	**Course name** Communication Networks I		
Instructor Prof. Dr.-Ing. Ralf Steinmetz		**Type** Lecture	**SWS** 3
Course Nr. 18-sm-1010-ue	**Course name** Communication Networks I		
Instructor Prof. Dr.-Ing. Ralf Steinmetz		**Type** Practice	**SWS** 1

Module name					
Communication Networks II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

Topics are:

- Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...)
- Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...)
- Transport Protocols (TCP, SCTP)
- Interactive Protocols (Telnet, SSH, FTP, ...)
- Electronic Mail (SMTP, POP3, IMAP, MIME, ...)
- World Wide Web (HTML, URL, HTTP, DNS, ...)
- Distributed Programming (RPC, Web Services, Event-based Communication)
- SOA (WSDL, SOAP, REST, UDDI, ...)
- Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...)
- Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...)
- Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...)
- VoIP and Instant Messaging (SIP, H.323)

2 Learning objectives / Learning Outcomes

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

3 Recommended prerequisite for participation

Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Selected chapters from following books:

- Andrew S. Tanenbaum: Computer Networks, Fourth 5th Edition, Prentice Hall, 2010
- James F. Kurose, Keith Ross: Computer Networking: A Top-Down Approach, 6th Edition, Addison-Wesley, 2009
- Larry Peterson, Bruce Davie: Computer Networks, 5th Edition, Elsevier Science, 2011

Courses

Course Nr.	**Course name**		
18-sm-2010-vl	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Lecture	3

Course Nr.	**Course name**		
18-sm-2010-ue	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Practice	1

Module name					
Natural Language Processing and the Web					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0433	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
German and English			Prof. Dr. techn. Johannes Fürnkranz		

1 Content

The Web contains more than 10 billion indexable web pages, which can be retrieved via keyword search queries. The lecture will present natural language processing (NLP) methods to automatically process large amounts of unstructured text from the web and analyze the use of web data as a resource for other NLP tasks.

Key topics:

- Processing unstructured web content
- NLP basics: tokenization, part-of-speech tagging, stemming, lemmatization, chunking
- UIMA: principles and applications
- Web contents and their characteristics, incl. diverse genres such as personal web sites, news sites, blogs, forums, wikis
- The web as a corpus – innovative use of the web as a very large, distributed, interlinked, growing, and multilingual corpus
- NLP applications for the web
- Introduction to information retrieval
- Web information retrieval and natural language interfaces
- Web-based question answering
- Mining Web 2.0 sites such as Wikipedia, Wiktionary
- Quality assessment of web contents
- Multilingualism
- Internet of services: service retrieval
- Sentiment analysis and community mining
- Paraphrases, synonyms, semantic relatedness

2 Learning objectives / Learning Outcomes

After attending this course, students are in a position to

- understand and differentiate between methods and approaches for processing unstructured text,
- reconstruct and explicate the principle of operation of web search engines,
- construct and analyze exemplary NLP applications for web data,
- analyze and evaluate the potential of using web contents to enhance NLP applications.

3 Recommended prerequisite for participation

Basic knowledge in Algorithms and Data Structure
Programming in Java

4 Form of examination

Module Eccompanying Examination:

- [20-00-0433-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-0433-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Kai-Uwe Carstensen, Christian Ebert, Cornelia Endriss, Susanne Jekat, Ralf Klabunde: Computerlinguistik und Sprachtechnologie. Eine Einführung. 3. Auflage. Heidelberg: Spektrum, 2009. ISBN: 978-3-8274-20123-7. - http://www.linguistics.rub.de/CLBuch/ - T. Götz, O. Suhre: Design and implementation of the UIMA Common Analysis System, IBM Systems Journal 43(3): 476–489, 2004. - Adam Kilgarriff, Gregory Grefenstette: Introduction to the Special Issue on the Web as Corpus, Computational Linguistics 29(3): 333–347, 2003. - Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval, Cambridge: Cambridge University Press, 2008. ISBN: 978-0-521-86571-5. http://nlp.stanford.edu/IR-book/

Courses

	Course Nr. 20-00-0433-iv	**Course name**	
	Instructor	**Type** Integrated Course	**SWS** 4

Module name					
Scalable Data Management Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1017	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** This course introduces the fundamental concepts and computational paradigms of scalable data management systems. The focus of this course is on the systems-oriented aspects and internals of such systems for storing, updating, querying, and analyzing large datasets. Topics include: Database Architectures Parallel and Distributed Databases Data Warehousing MapReduce and Hadoop Spark and its Ecosystem Optional: NoSQL Databases, Stream Processing, Graph Databases, Scalable Machine Learning
2	**Learning objectives / Learning Outcomes** After the course the student will have a good overview of the different concepts, algorithms, and systems aspects of scalable data management. The main goal is that the students will know how to design and implement such systems including hands-on experience with state-of-the-art systems such as Spark.
3	**Recommended prerequisite for participation** Programming in C++ and Java Informationsmanagement (20-00-0015-iv) Optional: Foundations of Distributed Systems (20-00-0998-iv)
4	**Form of examination** Module Eccompanying Examination: • [20-00-1017-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1017-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr.	**Course name**		
	20-00-1017-iv	Scalable Data Management Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Integrated Course	4

Module name					
Software Engineering - Introduction					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-1010	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture gives an introduction to the broad discipline of software engineering. All major topics of the field - as entitled e.g. by the IEEE's "Guide to the Software Engi-neering Body of Knowledge" - get addressed in the indicated depth. Main emphasis is laid upon requirements elicitation techniques (software analysis) and the design of soft-ware architectures (software design). UML (2.0) is introduced and used throughout the course as the favored modeling language. This requires the attendees to have a sound knowledge of at least one object-oriented programming language (preferably Java). During the exercises, a running example (embedded software in a technical gadget or device) is utilized and a team-based elaboration of the tasks is encouraged. Exercises cover tasks like the elicitation of requirements, definition of a design and eventually the implementation of executable (proof-of-concept) code.
2	**Learning objectives / Learning Outcomes** This lecture aims to introduce basic software engineering techniques - with recourse to a set of best-practice approaches from the engineering of software systems - in a practice-oriented style and with the help of one running example. After attending the lecture students should be able to uncover, collect and document essential requirements with respect to a software system in a systematic manner using a model-driven/centric approach. Furthermore, at the end of the course a variety of means to acquiring insight into a software system's design (architecture) should be at the student's disposal.
3	**Recommended prerequisite for participation** sound knowledge of an object-oriented programming language (preferably Java)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc iST, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se-i-v/

Courses

Course Nr.	Course name		
18-su-1010-vl	Software Engineering - Introduction		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr		Lecture	3
Course Nr.	**Course name**		
18-su-1010-ue	Software Engineering - Introduction		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Lars Fritsche		Practice	1

Module name					
Software-Engineering - Maintenance and Quality Assurance					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture covers advanced topics in the software engineering field that deal with maintenance and quality assurance of software. Therefore, those areas of the software engineering body of knowledge which are not addressed by the preceding introductory lecture, are in focus. The main topics of interest are: software maintenance and reengineering, configuration management, static programme analysis and metrics, dynamic programme analysis and runtime testing as well as programme transformations (refactoring). During the exercises, a suitable Java open source project has been chosen as running example. The participants analyze, test and restructure the software in teams, each dealing with different subsystems.
2	**Learning objectives / Learning Outcomes** The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. After attendance of the lecture a student should be familiar with all activities needed to maintain and evolve a software system of considerable size. Main emphasis is laid on software configuration management and testing activities. Selection and usage of CASE tool as well as working in teams in conformance with predefined quality criteria play a major role.
3	**Recommended prerequisite for participation** Introduction to Computer Science for Engineers as well as basic knowledge of Java
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se_ii/

Courses

Course Nr. 18-su-2010-vl	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Lecture	**SWS** 3
Course Nr. 18-su-2010-ue	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Practice	**SWS** 1

Module name Seminar Medical Data Science – Medical Informatics					
Module Nr. 18-mt-2240	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner**		

1	**Content** In the seminar „Medical Data Science – Medical Informatics", the students familiarize themselves with selected topics of recent conference and journal papers in the field of medical data science / medical informatics and finalize the course with an oral presentation. • critical reflections on the selected topic • further reading and individual literature review • preparation of a presentation (written and powerpoint) about the selected topic • presenting the talk in front of a group with heterogeneous prior knowledge • specialist discussion about the selected topic after the presentation The topics will derive from diverse medical applications from the field of medical data science / medical informatics such as standardized exchange formats of medical data or technical and semantic interoperability.
2	**Learning objectives / Learning Outcomes** After successful completion of the module, students are able to independently work themselves into a topic using scientific publications. • They learn to recognize relevant aspects of the selected study and to comprehensibly present the topic in front of a heterogeneous audience using different presentation techniques. After successful completion of the module, students are able to independently work themselves into a topic using scientific publications.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Details of the exam will be announced at the beginning of the course [presentation (30 minutes) and report] .
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** To be announced during the course.
Courses	

	Course Nr.	Course name		
	18-mt-2240-se	Seminar Medical Data Science – Medical Informatics		
	Instructor		**Type**	**SWS**
			Seminar	2

Module name Seminar Data Mining and Machine Learning					
Module Nr. 20-00-0102	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report. The papers will typically recent publications in relevant journals such as “Data Mining and Knowledge Discovery”, “”Machine Learning"", as well as ""Journal of Machine Learning Research"". Students may also propose their own topics if they fit the theme of the seminar. Please note current announcements to this course at http://www.ke.informatik.tu-darmstadt.de/lehre.
2	**Learning objectives / Learning Outcomes** After this seminar, students should be able to - understand an unknown text in the area of machine learning - work out a presentation for an audience proficient in this field - make useful contributions in a scientific discussion in the area of machine learning
3	**Recommended prerequisite for participation** Basic knowledge in Machine Learning and Data Mining
4	**Form of examination** Module Eccompanying Examination: • [20-00-0102-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0102-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 20-00-0102-se	**Course name** Seminar Data Mining and Machine Learning		
	Instructor		**Type** Seminar	**SWS** 2

Module name					
Extended Seminar - Systems and Machine Learning					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-1057	4 CP	120 h	75 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems. Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals. The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name
2	**Learning objectives / Learning Outcomes** After this seminar, the students should be able to - understand a new research contribution in the areas of the seminar - prepare a written report and present the results of such a paper in front of an audience - participate in a discussion in the areas of the seminar - to peer-review the results of other students
3	**Recommended prerequisite for participation** Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.
4	**Form of examination** Module Eccompanying Examination: • [20-00-1057-se] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1057-se] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B. Sc Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr.	**Course name**		
	20-00-1057-se	Extended Seminar - Systems and Machine Learning		
	Instructor		**Type**	**SWS**
	Prof. Dr. techn. Johannes Fürnkranz		Seminar	3

Module name Project seminar „Medical Data Science – Medical Informatics“					
Module Nr. 18-mt-2250	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner**		

1	**Content** In this project seminar „Medical Data Science – Medical Informatics", students are involved in planning, realization and further development of novel applications. This practical course covers topics such as data acqusition and data processing in the clinic for example for health care and research, for patient registries or for further innovative topics of public-funded research projects.
2	**Learning objectives / Learning Outcomes** • Knowledge: In this project seminar, students will get practical training in the field of medical informatics through active integration into the working group and learn about typical challenges in the clinical context such as data protection or data integration. Furthermore, knowledge about medical classifications and standardized exchange formats will be conveyed. • Skills: Students will deepen their skills in software development particularly through their active integration into open source projects in the clinical context as well as the communication/networking within software projects. • Competences: Participants will be able to apply and largely independently develop discipline-relevant technologies. In group work, they acquire the ability for independent realization of elements of larger software solutions.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) The type of examination will be announced in the first lecture. Possible types include presentation (30 minutes), documentation.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** *M.Sc. Biomedical Engineering*
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be announced during the project seminar.

Courses

Course Nr. 18-mt-2250-pj	**Course name** Project seminar „Medical Data Science – Medical Informatics“	
Instructor	**Type** Project Seminar	**SWS** 4

Module name					
Multimedia Communications Project I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-1030	9 CP	270 h	210 h	1	WiSe/SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with cutting edge scientific and development topics in the area of multimedia communication systems. Besides a general overview, it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics:

- Network planning and traffic analysis
- Performance evaluation of network applications
- Discrete event simulation for network services
- Protocols for mobile ad hoc networks / sensor networks
- Infrastructure networks for mobile communication / mesh networks
- Context-aware communication and services
- Peer-to-peer systems and architectures
- Content distribution and management systems for multimedia/e-learning
- Multimedia authoring and re-authoring tools
- Web service technologies and service-oriented architectures
- Applications for distributed workflows
- Resource-based Learning

2 Learning objectives / Learning Outcomes

The ability to solve and evaluate technical problems in the area of design and development of future multimedia communication networks and applications using state of the art scientific methods. Acquired competences are among the following:

- Searching and reading of project relevant literature
- Design of communication applications and protocols
- Implementing and testing of software components
- Application of object-orient analysis and design techniques
- Acquisition of project management techniques for small development teams
- Evaluation and analyzing of technical scientific experiments
- Writing of software documentation and project reports
- Presentation of project advances and outcomes

3 Recommended prerequisite for participation

Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communication systems. Further we expect:

- Basic experience in programming Java/C# (C/C++).
- Basic knowledge in Object oriented analysis and design.
- Knowledge in computer communication networks. Lectures in Communication Networks I and/or Net Centric Systems are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6	**Usability of this module** BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS
7	**Grade bonus compliant to §25 (2)**
8	**References** Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books: • Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887) • Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	**Course name**		
18-sm-1030-pj	Multimedia Communications Project I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer		Project Seminar	4

Module name					
Multimedia Communications Lab I					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-1020	3 CP	90 h	45 h	1	WiSe/SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with cutting edge development topics in the area of multimedia communication systems. Beside a general overview it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competences in one or more of the following topics:

- Network planning and traffic analysis
- Performance evaluation of network applications
- Discrete event simulation for network services
- Protocols for mobile ad hoc networks / sensor networks
- Infrastructure networks for mobile communication / mesh networks
- Context-aware communication and services
- Peer-to-peer systems and architectures
- Content distribution and management systems for multimedia/e-learning
- Multimedia authoring and re-authoring tools
- Web service technologies and service-oriented architectures
- Applications for distributed workflows
- Resource-based Learning

2 Learning objectives / Learning Outcomes

The ability to solve simple problems in the area of multimedia communication shall be acquired. Acquired competences are:

- Design of simple communication applications and protocols
- Implementing and testing of software components for distributed systems
- Application of object-oriented analysis and design techniques
- Presentation of project advances and outcomes

3 Recommended prerequisite for participation

Keen interest to explore basic topics of cutting edge communication and multimedia technologies. Further we expect:

- Basic experience in programming Java/C# (C/C++).
- Knowledge in computer communication networks. Lectures in Communication Networks I and/or Net Centric Systems are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

BSc ETiT, BSc/MSc iST, MSc MEC, Wi-CS, Wi-ETiT, BSc/MSc CS

7 Grade bonus compliant to §25 (2)

8 References

Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books:

- Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887)
- Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385)
- Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	**Course name**		
18-sm-1020-pr	Multimedia Communications Lab I		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer		Internship	3

Module name					
C/C++ Programming Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-1030	3 CP	90 h	45 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The six-day programming lab is divided into two sections. In the first four days, the programming languages C and C++ are taught with practical tasks and lectures. All covered aspects are extensively practiced under supervision. Based on the fundamental basics of C++, manual memory management and dynamic data structures are handled from a procedural as well as from an object-oriented perspective. Object orientation with C++ is extensively addressed by treating multiple inheritance, polymorphism and parametric polymorphism. The last two days are dedicated to microcontroller programming in C including the opportunity of programming of a distributed application (via a CAN-bus).
2	**Learning objectives / Learning Outcomes** During the lab, the students acquire a fundamental understanding of the programming languages C and C++ with emphasis not only on procedural but also on object-oriented characteristics. The students gain hands-on experience with applying C++ and discover the challenges of using C++ safely and properly especially in the context of embedded system software development.
3	**Recommended prerequisite for participation** Java skills
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc ETiT, BSc MEC, BSc iST, BSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** http://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/c-und-c-p

Courses

Course Nr.	Course name		
18-su-1030-pr	C/C++ Programming Lab		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Andreas Schürr		Internship	3

Module name Data Management - Lab					
Module Nr. 20-00-1041	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab. Possible areas are: - Scalable Databases & Modern Hardware - Cloud Databases & Blockchains - Interactive Data and Text Exploration - Natural Language Interfaces for Databases - Scalable Systems for Machine Learning In this lab the students will realise a project defined by their advisor. Compared to the “Data Management - Lab”, the “Data Management - Extended Lab” requires more effort.
2	**Learning objectives / Learning Outcomes** After completion of this course the students are able to - Understand state-of-the-art techniques in modern data management systems - Apply and implemenation of techniques in individual projects - Provide experimental evidence for design decisions with benchmarks and/or real workloads
3	**Recommended prerequisite for participation** Depending on selected topic.
4	**Form of examination** Module Eccompanying Examination: • [20-00-1041-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1041-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr. 20-00-1041-pr	**Course name** Data Management - Lab		
	Instructor Prof. Dr. techn. Johannes Fürnkranz		**Type** Internship	**SWS** 4

Module name Data Management - Extended Lab					
Module Nr. 20-00-1042	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 180 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. techn. Johannes Fürnkranz		

1	**Content** Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab. Possible areas are: - Scalable Databases & Modern Hardware - Cloud Databases & Blockchains - Interactive Data and Text Exploration - Natural Language Interfaces for Databases - Scalable Systems for Machine Learning In this lab the students will realise a project defined by their advisor. Compared to the “Data Management - Lab”, the “Data Management - Extended Lab” requires more effort.
2	**Learning objectives / Learning Outcomes** After completion of this course the students are able to - Understand state-of-the-art techniques in modern data management systems - Apply and implemenation of techniques in individual projects - Provide experimental evidence for design decisions with benchmarks and/or real workloads
3	**Recommended prerequisite for participation** Depending on selected topic.
4	**Form of examination** Module Eccompanying Examination: • [20-00-1042-pp] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1042-pp] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

Course Nr. 20-00-1042-pp	**Course name** Data Management - Extended Lab	
Instructor Prof. Dr. techn. Johannes Fürnkranz	**Type** Project	**SWS** 6

5.3 Optional Subarea Entrepreneurship and Management (EM)

5.3.1 EM - Lectures (Basis Modules)

Module name Introduction to Business Administration					
Module Nr. 01-10-1028/f	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. rer. pol. Dirk Schiereck		

1	**Content** This course serves as an introduction into studies of business administration for students of other siences. The course will provide a broad spectrum of knowledge from the "birth" of business administration as an university science field until its fragmentation into many specialized disciplines. Core topics will include basics of business administration (definitions and German legal forms), some Marketing concepts, introduction into Production Management (business process optimization and quality management), basic knowledge of organisational and personnel related topics, fundamental concepts of finance and investment as well as internal and external reporting standards.
2	**Learning objectives / Learning Outcomes** The couse encourages students who have not been confronted with business studies before to think economicially. Furthermore, it should enable students to better understand actions of managers and corporations in general. After the course students are able to • comprehend the development in the history of business administration, • apply essential marketing concepts, • use fundamental methods in production management, • economically valuate investment alternatives and • understand important interrelations in financial accounting.
3	**Recommended prerequisite for participation** None
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** Thommen, J.-P. & Achleitner, A.-K. (2006): Allgemeine Betriebswirtschaftslehre, 5. Aufl., Wiesbaden. Domschke, W. & Scholl, A. (2008): Grundlagen der Betriebswirtschaftslehre, 3. Aufl., Heidelberg. Further literature will be announced in the lecture.
Courses	

	Course Nr. 01-10-0000-vl	**Course name** Introduction to Business Administration		
	Instructor		**Type** Lecture	**SWS** 2
	Course Nr. 01-10-0000-tt	**Course name**		
	Instructor Prof. Dr. rer. pol. Dirk Schiereck		**Type** Tutorial	**SWS** 0

Module name					
Financial Accounting and Reporting					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-14-1B01	5 CP	150 h	60 h	1	Every Sem.
Language			**Module owner**		
German			Prof. Dr. rer. pol. Reiner Quick		

1	**Content** Financial Accounting: Fundamentals of accounting and bookkeeping, inventory, balance sheet, recording of assets and debt, recording of expenses and revenues, selected transactions (sales and purchases, non-current assets, current assets, accruals, wage and salary, distribution of earnings), annual closing entry. Financial Reporting: Fundamentals of accounting based on the rules of the German Commercial Code (HGB), accounting concepts, purpose of accounting, bookkeeping, inventory, recognition and measurement of assets and liabilities, income statement, notes, management report.
2	**Learning objectives / Learning Outcomes** After the course students are able to • understand the core principles of bookkeeping, inventory and preparation of the balance sheet • book stocks and profit • solve specific bookkeeping problems in the fields of sales and purchases, non-current and current assets, accruals, wage and salary, distribution of earnings • understand of the steps prior to the preparation of annual financial statements according to the German Commercial Code (HGB) • analyze of the recognition and measurement of assets and liabilities • understand of Income statements, notes and management reports • solve accounting cases in the context of the German Commercial Code (HGB)
3	**Recommended prerequisite for participation** Prerequisites: none Previous Knowledge: see initial skills
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Duration: 45 min, Standard Grading System) • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System) Supplement to Assessment Methods: The academic achievement needs to be passed to take part in the module exam.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 1) • Module Examination (Technical Examination, Written Examination, Weighting: 2)
6	**Usability of this module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Quick, R./ Wurl, H.-J: Doppelte Buchführung, 2. Aufl., Wiesbaden: Gabler. Quick, R./Wolz, M.: Bilanzierung in Fällen. 4. Auflage. Schäffer Poeschel, Stuttgart Further literature will be announced in the lecture.
Courses	

	Course Nr. 01-14-0001-vu	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture & Practice	**SWS** 2
	Course Nr. 01-14-0003-vu	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Lecture & Practice	**SWS** 2
	Course Nr. 01-14-0003-tt	**Course name** Financial Accounting		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1
	Course Nr. 01-14-0001-tt	**Course name** Bookkeeping		
	Instructor Prof. Dr. rer. pol. Reiner Quick		**Type** Tutorial	**SWS** 1

Module name					
Introduction to Entrepreneurship					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-27-1B01	3 CP	90 h	45 h	1	Every Sem.
Language			**Module owner**		
German			Prof. Dr. rer. pol. Carolin Bock		

1 Content

The course “Grundlagen des Entrepreneurship” (Introduction to Entrepreneurship), being part of the module "Grundlagen Entrepreneurship" introduces concepts of entrepreneurship relying on basic concepts and definitions. Hereby, a global and international perspective is taken. The course includes the topics: actions of entrepreneurs, their motivations and idea generating processes, effectuation and causation, their decision-making, and entrepreneurial failure. Concerning entrepreneurial businesses, business planning, growth models, strategic alliances of young ventures, and human and social capital of entrepreneurs are discussed, Further, special types of entrepreneurship are taught. In addition, workshops will give students an insight into practical methods such as design thinking and the implementation and identification of opportunities.

2 Learning objectives / Learning Outcomes

After the course students are able to

- define and describe basic concepts towards entrepreneurship,
- understand the psychologically-related concepts of being an entrepreneur,
- understand and describe the evolution from small firms to multinational enterprises,
- describe special types of entrepreneurship,
- understand basic concepts of entrepreneurial thinking towards idea- and business model creation,
- realize business opportunities and build sustainable business models,
- evaluate chances and risks of national and international markets as well choosing among various market entry strategies,
- incorporate stakeholder feedback into the business model.

3 Recommended prerequisite for participation

Prerequisites: none

Previous Knowledge: see initial skills and basics in business administration

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 60 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik

7 Grade bonus compliant to §25 (2)

8 References

Grichnik, D., Brettel, M., Koropp, C., Mauer, R. (2010) Entrepreneurship. Stuttgart: Schäffer-Poeschel Verlag

Hisrich, R. D., Peters, M. P., & Shepherd, D. A. (2010). Entrepreneurship (8th ed.). New York: McGraw-Hill.

Read, S., Sarasvathy, S., Dew, N., Wiltbank, R. & Ohlsson, A.-V. (2010). Effectual Entrepreneurship. New York: Routledge Chapman & Hall.

More literature will be provided within the course and distributed to the students accordingly

Courses				
	Course Nr. 01-27-1B01-vl	**Course name** Introduction to Entrepreneurship		
	Instructor Prof. Dr. rer. pol. Carolin Bock		**Type** Lecture	**SWS** 3

Module name Introduction to Innovation Management					
Module Nr. 01-22-2B01	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every Sem.
Language English			**Module owner** Prof. Dr. Alexander Kock		

1	**Content** The lecture offers students an introduction to the topic of innovation management in companies. In times of disruptive and radical innovations, well-founded knowledge in innovation management is an elementary core competence of companies in order to stay competitive. After learning the conceptual basics, students learn about managing the different stages of the innovation process, from initiative to the adoption of an innovation. In addition, strategic aspects and the human side of innovation management will be introduced. The lecture thus forms an excellent thematic orientation and introduction for undergraduate students for the advanced courses of the master studies.
2	**Learning objectives / Learning Outcomes** After the course students are able to • give an overview of the components of the innovation process and management. • identify and evaluate problems that arise in the management of innovations. • explain, evaluate and apply theories of technology and innovation management. • assess the basic design factors of a firm's innovation system. • derive actions to improve innovation processes in companies. • apply the concepts to practice-relevant questions.
3	**Recommended prerequisite for participation** Prerequisites: none Previous Knowledge: see initial skills and basics in business administration
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik
7	**Grade bonus compliant to §25 (2)**
8	**References** Hauschildt, J., Salomo, S., Schultz. C., Kock, A. (2016): Innovationsmanagement, 6. Aufl. Vahlen Verlag. Tidd/Bessant (2013): Managing Innovation: Integrating Technological, Market and Organizational Change. Further literature will be announced in the lecture.

Courses

Course Nr. 01-22-2B01-vl	**Course name**		
Instructor Prof. Dr. Alexander Kock		**Type** Lecture	**SWS** 2

Module name Human Resources Management					
Module Nr. 01-17-1036	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 45 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. rer. pol. Ruth Stock-Homburg		

1 Content

- Theoretical foundation of HR management
- Selected approaches regarding employee flow systems
- Selected approaches regarding reward system
- New challenges for HR management

2 Learning objectives / Learning Outcomes

After the courses the students are able to

- know a comprehensive overview of HR management.
- classify and critically review the elements of employee flow systems.
- understand the characteristics of reward systems from a theoretical and practical perspective.
- understand the importance of senior executives and employees for companies' success.
- recognize new challenges in designing work-life balance of executives and employees.
- understand the relevance of the topics with regards to management practice.

3 Recommended prerequisite for participation

Prerequisites: none

Previous Knowledge: see initial skills and basics in business administration

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik

7 Grade bonus compliant to §25 (2)

8 References

Compulsory Reading:

Stock-Homburg, R. (2013), Personalmanagement: Theorien – Konzepte – Instrumente, 3. Auflage, Wiesbaden.

Further Reading:

Baruch, Y. (2004), Managing Careers: Theory and Practice, Harlow.

Gmür, M., Thommen, J.-P. (2007), Human Resource Management: Strategien und Instrumente für Führungskräfte und das Personalmanagement, 2. Auflage, Zürich.

Mondy, R. W. (2011), Human Resource Management, 12. Auflage, New Jersey.

Oechsler, W. (2011), Personal und Arbeit – Grundlagen des Human Resource Management und der Arbeitgeber-Arbeitnehmer-Beziehungen, 9. Auflage, Oldenbourg.

Further literature will be announced in the lecture.

Courses

	Course Nr.	Course name		
	01-17-0003-vu	Human Ressources Management		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. pol. Ruth Stock-Homburg		Lecture & Practice	3

Module name Management of value-added networks					
Module Nr. 01-12-0B02	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. rer. pol. Ralf Elbert		

1 Content

The students get an overview of the management of value-added networks. The fundamentals and theories of international management will be covered as well as strategy and strategy design (strategy design at company and business level, strategic analysis, strategic management in multinational companies). Furthermore, fundamentals of organization and organizational design (structural and procedural organization, organization of international networks) are discussed. Regarding methodological knowledge for the management of value-added networks, the fundamentals of planning and decision-making (decision theories and decision techniques) as well as an introduction to simulation modeling is provided to the students.

2 Learning objectives / Learning Outcomes

After the course students are able to

- reproduce basic knowledge on the management of value-added networks
- apply basic knowledge for the management of value-creating networks in practical situations
- apply different decision techniques in real-world examples establish links between the basic knowledge on the management of value-added networks and further courses in business economics
- reproduce the concepts of strategy design conveyed at different levels and to apply them in the context of practice
- understand and reproduce different models for structural and procedural organization

3 Recommended prerequisite for participation

Prerequisites: none

Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik

7 Grade bonus compliant to §25 (2)

8 References

Further literature will be announced in the lecture.

Courses

Course Nr.	**Course name**		
01-12-0001-vu	Management of value-added networks		
Instructor		**Type**	**SWS**
Prof. Dr. rer. pol. Ralf Elbert		Lecture	3

Module name Introduction to Law					
Module Nr. 01-40-1033/f	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every Sem.
Language German and English			**Module owner** Prof. Dr. jur. Janine Wendt		

1 Content

The lecture provides a broad insight into the most important legal fields of daily life - e.g.:

- The law of sales contracts
- Tenancy law
- Family law
- Employment law
- Corporate law etc.

These will be illustrated by means of practical cases. Important points of how to frame a contract will be discussed.

2 Learning objectives / Learning Outcomes

The students will acquire knowledge of the basic principles of German civil law.

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

BGB-Gesetzestext(z.B. Beck-Texte im dtv)
Materialien zum Download auf der Homepage des Fachgebiets.

Courses

Course Nr. 01-40-0000-vl	**Course name** Introduction to Law	
Instructor Prof. Dr. jur. Janine Wendt	**Type** Lecture	**SWS** 2

Module name					
German and International Corporate Law					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-42-1B01/4	4 CP	120 h	75 h	1	Every Sem.
Language			**Module owner**		
German			Prof. Dr. jur. Janine Wendt		

1 Content

The lecture is divided into two parts: The first part is an introduction to commercial law. The aim is to understand the importance of contract drafting in a company and to take into account the main aspects of commercial law regulations. The second part is devoted to company law, in particular the law of commercial partnerships and corporations. It also deals with the basic issues of good corporate governance and the importance of compliance. European company law will also be introduced.
Recitation: This course discusses practical cases concerning commercial law and general company law. In preparation for the exam, sample cases will be discussed.

2 Learning objectives / Learning Outcomes

After the course students are able to

- recognise the conditions for the application of commercial law.
- distinguish between the different commercial intermediaries.
- understand the basic structures of the most important forms of partnerships and corporations as legal entities for companies.
- understand the importance of good corporate governance and the importance of compliance for companies.
- deal with different legal texts.
- understand the significance of European legal developments for German law and in particular for the protection of investors.
- understand the context of legal regulations (e.g. sales law + commercial law + company law).
- work on simple facts of the German commercial and company law, as well as the financial market law by applying a legal approach and to compile answers to simple legal questions independently.
- generally recognise, assess and respond to the possibilities and risks of liability in legal matters.

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills and contract law

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Wirtschaftsingenieurwesen, B.Sc. Wirtschaftsinformatik

7 Grade bonus compliant to §25 (2)

8 References

	Wendt, J., Wendt, D. (2019): Finanzmarktrecht, 1. Aufl. De Gruyter Verlag. Buck-Heeb, P. (2017): Kapitalmarktrecht, 9. Aufl. C.F. Müller Verlag Poelzig, D. (2017): Kaptalmarktrecht, 1. Aufl. C.H. Beck Verlag Brox/Henssler, Handelsrecht Kindler, Grundkurs Handels- und Gesellschaftsrecht Further literature will be announced in the lecture.

Courses

	Course Nr. 01-42-0001-vl	**Course name** German and International Corporate Law		
	Instructor Prof. Dr. jur. Janine Wendt		**Type** Lecture	**SWS** 2
	Course Nr. 01-42-0001-ue	**Course name** German and International Corporate Law		
	Instructor Prof. Dr. jur. Janine Wendt		**Type** Practice	**SWS** 1

Module name Introduction to Economics (V)					
Module Nr. 01-60-1042/f	**Credit Points** 3 CP	**Workload** 90 h	**Self study** 60 h	**Duration** 1	**Cycle offered** Every Sem.
Language German and English			**Module owner** Prof. Dr. rer. pol. Michael Neugart		

1 Content

- Economic modeling
- Supply and demand
- Elasticities
- Consumer and producer rent
- Opportunity costs
- Marginal analysis
- Cost theory
- Utility maximization
- Macroeconomic aggregates
- Long-run growth
- Aggregate supply and aggregate demand

2 Learning objectives / Learning Outcomes

Students are introduced to the principles of economics and their application to selected fields of interest.

3 Recommended prerequisite for participation

None

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

none

7 Grade bonus compliant to §25 (2)

8 References

to be announced in course.

Courses

Course Nr.	Course name		
01-60-0000-vl	Introduction to Economics		
Instructor		**Type** Lecture	**SWS** 2

Module name Digital Product and Service Marketing					
Module Nr. 01-17-6200/6	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language English			**Module owner** Prof. Dr. rer. pol. Ruth Stock-Homburg		

1 Content

Digital Product and Service Marketing: Selected instruments of various phases of customer relationship management (analysis, strategic management, operations management, implementation, control) in the era of digitalization; challenge of digital marketing channels; potential of social media marketing and influencer marketing; e-commerce; sustainability and ethical responsibility in digital marketing.
Digital Innovation Marketing: Fundamentals and differences of B2B/B2C marketing; significance and fundamentals of innovation management in the era of digitization; process and design elements of customer-oriented innovation management; digital innovations, user innovations and crowd-based innovations; significance of digital idea management; co-creation and role of the customer; innovative digital business models.

2 Learning objectives / Learning Outcomes

After the course students are able to

- Evaluate approaches to analyzing customer relationships.
- Explain different phases and tools for managing customer relationships.
- Recognize the role of digitization for marketing and to estimate potentials.
- Evaluate selected marketing management concepts in the B2B and B2C context.
- Explain the process and the organizational design elements of a holistic and customer-oriented innovation management.
- Recognize the potential of user innovations and crowd-based innovation and to reflect on the role of the customer.
- Critically reflect on ethical aspects of marketing.
- Apply the concepts and instruments dealt with to practice-relevant questions in the form of case studies.
- Transfer the learned contents to business practice through guest lectures.

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods
Oral/written: Type and duration of exam are announced by the beginning of the course
Written: exam (duration 60 - 90 minutes)
Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

Digitales Produkt- und Dienstleistungsmarketing:
Bruhn, M. (2012): Relationship Marketing, München, 3. Auflage, Homburg, C../Stock-Homburg, R. (2011): Theoretische Perspektiven der Kundenzufriedenheit, in: Homburg, C. (Hrsg.), Kundenzufriedenheit: Konzepte, Methoden, Erfahrungen, Wiesbaden, 8. Auflage,
Stock-Homburg, R. (2011), Der Zusammenhang zwischen Mitarbeiter- und Kundenzufriedenheit: Direkte, indirekte und moderierende Effekte, Wiesbaden, 5. Auflage, Stauss, B., Seidel, W. (2007), Beschwerdemanagement: Unzufriedene Kunden als profitable Zielgruppe, München, 4. Auflage.
Digital Innovation Marketing:
Homburg, C. (2012), Marketingmanagement: Strategie – Instrumente – Umsetzung – Unternehmensführung, Wiesbaden, 4. Auflage, Szymanski, D. M., Kroff, M. W., Troy, L. C. (2007), Innovativeness and New Product Success: Insights from the Cumulative Evidence, Journal of the Academy of Marketing Science, 35(1), 35-52.Hauser, J., Tellis, G. J., Griffin, A. (2006), Research on Innovation: A Review and Agenda for Marketing Science, Marketing Science, 25(6), 687-717, von Hippel, E. (2005), Democratizing Innovation, Cambridge, Kapitel 9-11.
Further literature will be announced in the lecture.

Courses

Course Nr.	**Course name**		
01-17-0007-vu	Digital Innovation Marketing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. pol. Ruth Stock-Homburg		Lecture & Practice	2

Course Nr.	**Course name**		
01-17-0005-vu	Digital Product and Service Marketing		
Instructor		**Type**	**SWS**
Prof. Dr. rer. pol. Ruth Stock-Homburg		Lecture & Practice	2

Module name Leadership and Human Resource Management Systems					
Module Nr. 01-17-6201/6	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language English			**Module owner** Prof. Dr. rer. pol. Ruth Stock-Homburg		

1 Content

Leadership:

- Approaches, selected instruments and international aspects of employee and team leadership
- Instruments for evaluating one's own leadership potential and leadership style
- Conceptual approaches and success factors of leadership
- Leadership of the future
- Special application areas of leadership (e.g. regional distributed or virtual leadership)

Future of Work:

- Influence of new technologies and digitization on the world of work
- Future development and design approaches in human resources management
- Approaches to measuring the sustainability of companies and individuals
- Special challenges of the future of work (e.g. work-life balance, electronic accessibility, working via platforms)

2 Learning objectives / Learning Outcomes

After the course students are able to,

- comprehend the main theoretical concepts of leading employees and teams.
- apply the instruments and tools available for leading employees and teams.
- apply learned concepts and instruments in case studies.
- connect their knowledge to business cases in presentations of experienced practitioners.

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods
Oral/written: Type and duration of exam are announced by the beginning of the course
Written: exam (duration 60 - 90 minutes)
Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

Stock-Homburg, Ruth (2013): Personalmanagement: Theorien – Konzepte – Instrumente, Wiesbaden, 3. Auflage.
Further literature will be announced in the lecture.

Courses				
	Course Nr. 01-17-0008-vu	**Course name** Future of Work		
	Instructor Prof. Dr. rer. pol. Ruth Stock-Homburg		**Type** Lecture & Practice	**SWS** 2
	Course Nr. 01-17-0004-vu	**Course name** Leadership		
	Instructor Dr. rer. pol. Gisela Gerlach		**Type** Lecture & Practice	**SWS** 2

Module name Project Management					
Module Nr. 01-19-1350/6	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language English			**Module owner** Prof. Dr. rer. pol. Andreas Pfnür		

1 Content

Project management I: Basics of planning and decision making for projects, project goals, generation of project alternatives, separation basics in configuration management, project definition, program – portfolio, stake-holder management and communication, quality management, scope and change management, human re-sources management for projects / project managers

Project management II: Strategic goals, separation and linking of projects; project portfolio planning; multi project management; organizational structures of multi project management; tools to select project alternatives; tools for project controlling; project management as professional service.

2 Learning objectives / Learning Outcomes

After the course students are able to

- understand the strategic goals of project management, the methods of choosing realization alternatives and the methods of project controlling
- understand the various subsystems of project management (e.g. Configuration Management, Human Resource Management, Stakeholder Management, Risk Management)
- understand the principles, methods and organization of multi project management

3 Recommended prerequisite for participation

Prerequisites: none

Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods

Oral/written: Type and duration of exam are announced by the beginning of the course

Written: exam (duration 60 - 90 minutes)

Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK Guide) 5th Edition

Further literature will be announced in the lecture.

Courses

Course Nr. 01-19-0001-vu	**Course name** Project Management I	
Instructor	**Type** Lecture & Practice	**SWS** 2

	Course Nr.	Course name		
	01-19-0003-vu	Project Management II		
	Instructor		**Type**	**SWS**
	Prof. Dr. Alexander Kock		Lecture & Practice	2

Module name					
Technology and Innovation Management					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-22-0M05/6	6 CP	180 h	120 h	1	Every Sem.
Language			**Module owner**		
English			Prof. Dr. Alexander Kock		

1 Content

The lecture Technology and Innovation Management is designed for the students to learn about the challenges of managing innovation. Organizational change and innovation are the basic requirements for competitiveness and success of businesses. However, in most industries innovation is often paired with organizational challenges and barriers. In this lecture, students get to know the fundamental concepts and design of Innovation Management and the innovation process (form initiative to implementation), as well as the interaction of central actors. Furthermore, this lecture provides insights into the specialisations Innovation Behaviour and Strategic Technology and Innovation Management.

2 Learning objectives / Learning Outcomes

After the course the students are able to

- identify and evaluate problems emerging from managing innovation.
- explain, evaluate and apply theories of Technology and Innovation Management.
- evaluate fundamental design factors of corporate innovation systems.
- derive improvement procedures for innovation processes in firms.
- apply tools of technology management.
- make relevant recommendations for corporate practice.

3 Recommended prerequisite for participation

Prerequisites: none

Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods

Oral/written: Type and duration of exam are announced by the beginning of the course

Written: exam (duration 60 - 90 minutes)

Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

Hauschildt, J., Salomo, S., Schultz. C., Kock, A. (2016): Innovationsmanagement, 6. Aufl. Vahlen Verlag, Tidd/Bessant (2013): Managing Innovation: Integrating Technological, Market and Organizational Change.

Further literature will be announced in the lecture.

Courses

	Course Nr.	Course name		
	01-10-1M01-vu	Technology and Innovation Management		
	Instructor		**Type**	**SWS**
	Prof. Dr. Alexander Kock		Lecture & Practice	4

Module name					
Entrepreneurial Strategy, Management & Finance					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-27-2M03/6	6 CP	180 h	120 h	1	Every Sem.
Language			**Module owner**		
English			Prof. Dr. rer. pol. Carolin Bock		

1 Content

Entrepreneurial Strategy & Management: In the course „Entrepreneurial Strategy & Management" important aspects of the entrepreneurial process and of establishing an entrepreneurial company are covered. Special focus, among others, is the commercialization of opportunities, the design and implementation of business models, and the development of innovation strategies. Students get an overview on entrepreneurial methods (design thinking, scrum, rapid prototyping) and strategy tools (strategy process, firm resources and capabilities, competitive advantage). Further, the successful definition and analysis of a target group and financial modeling are core topics. Content is in part discussed via case studies and insights from practitioners give valuable grounds for discussions.
Entrepreneurial Finance: In the course "Entrepreneurial Finance", special attention is put on sources of financing which are relevant in different development stages of start-ups, e.g. subsidies, business angels, crowdfunding, etc. Students get an overview of different sources of funding available for young companies and their advantages and disadvantages. This part also provides a broad overview of the venture capital industry. Further, the business model of venture capital firms and the relationship between an equity investor and an entrepreneurial firm are analyzed in more detail. Based on a general understanding of the venture capital industry, the refinancing and investment process of a venture capital firm will be discussed intensively.

2 Learning objectives / Learning Outcomes

Study goals Entrepreneurial Strategy & Management: Students gain in-depth knowledge on theoretical concepts and methods important in the field of managing young companies. Three main objectives of the course are:

- describe and understand core concepts of managing an entrepreneurial company
- understand and analyze tools and techniques for developing successful business models
- evaluate strategic decision-making processes for young companies

Study goals Entrepreneurial Finance: Students gain in-depth knowledge on theoretical concepts and methods important in the field of financing young companies. Within the course, both young ventures as well as established entrepreneurial firms are considered. Three main objectives of the course are:

- to understand challenges of financing entrepreneurial firms,
- to analyze the suitability of different sources of financing for entrepreneurial firms and to know their strengths and weaknesses,
- to analyze tools and techniques of finance for entrepreneurial firms in early and later development stages, thereby focusing on private capital markets with an emphasis

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods:
Oral/written: Type and duration of exam are announced by the beginning of the course
Written: exam (duration 60 - 90 minutes)
Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

	Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
7	**Grade bonus compliant to §25 (2)**
8	**References** Entrepreneurial Strategy & Management: Grant, R. M. (2016): Contemporary Strategy Analysis. Entrepreneurial Finance: Timmons, J./ Spinelli, S. (2007): New Venture Creation: Entrepreneurship for the 21st century, Boston. Amis, D. / Stevenson, H. (2001): Winning Angels, London Scherlis, D. R. / Sahlman, W. A. (1989): A Method for Valuing High-Risk, Long-Term Investments - The "Venture Capital Method", Harvard Business School, Boston. Further literature will be announced in the lecture.

Courses

	Course Nr. 01-27-1M02-vu	**Course name** Entrepreneurial Strategy & Management	
	Instructor Prof. Dr. rer. pol. Carolin Bock	**Type** Lecture & Practice	**SWS** 2
	Course Nr. 01-27-1M01-vu	**Course name** Entrepreneurial Finance	
	Instructor Prof. Dr. rer. pol. Carolin Bock	**Type** Lecture & Practice	**SWS** 2

Module name Venture Valuation					
Module Nr. 01-27-2M01/6	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language English			**Module owner** Prof. Dr. rer. pol. Carolin Bock		

1 Content

In the course, special attention is put on valuation techniques for start-up companies (ventures) while also considering the special environment these firms operate in. Students will receive an overview of different valuation techniques applicable for the valuation of entrepreneurial ventures. The course will elaborate on generic and commonly used practices but also introduce students into case-specific valuation methods. Further, standard valuation methods will be analysed as to their applicability in different contexts. Valuation methods include the discounted cash flow and multiple approach. In addition, context-specific approaches to new venture valuation are considered. Furthermore, students are offered the opportunity to collect hands-on experience while applying the methods taught in exercises and case studies.

2 Learning objectives / Learning Outcomes

After the course students are able to,

- Objectives: Students gain in-depth knowledge on theoretical concepts and methods in the field of valuing young companies. After the course, students are able:
- to understand different valuation methods for young companies and to apply them according to practical examples,
- to discuss the advantages and disadvantages of valuation techniques for young companies,
- to understand the challenges of determining “the right value” for young companies.

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods
Oral/written: Type and duration of exam are announced by the beginning of the course
Written: exam (duration 60 - 90 minutes)
Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

Achleitner, A-K. / Nathusius, E. (2004): Venture Valuation – Bewertung von Wachstumsunternehmen, Freiburg, Smith, J. Kiholm / Smith, R. L. / Bliss, Richard T. (2011): Entrepreneurial Finance: strategy, valuation and deal structure, Stanford California.
Further literature will be announced in the lecture.

Courses

	Course Nr.	Course name		
	01-27-2M01-vu	Venture Valuation		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. pol. Carolin Bock		Lecture & Practice	4

Module name Sustainable Management					
Module Nr. 01-42-0M02/6	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner** Prof. Dr. jur. Janine Wendt		

1 Content

Corporate Governance: the German dual board management system versus the legal structure of the European Company (Societas Europaea, SE) – legal regulations for management and supervision – checks and balances – international and national acknowledged standards for good and responsible corporate governance – sustainable value creation in line with the principles of the social market economy – compliance with the law, but also ethically sound and responsible behaviour – the "reputable businessperson – German Corporate Governance Code (the "Code")
Quality and Environmental Management: Sustainability and Corporate Social Responsibility: Approaches, Opportunities and Challenges for Companies - Relationships to Corporate Governance and Compliance Management - Goals of Quality and Environmental Management - Sustainability-Oriented Management Systems, especially Quality, Environmental and Energy Management Systems - Quality Management Instruments - Environmental Management Instruments - External Sustainability Reporting - Implementation of Quality and Environmental Management in Companies: Guest Lectures from Corporate Practice

2 Learning objectives / Learning Outcomes

After the course students are able to

- describe the various legal forms of organization and their pros and cons
- present the essential statutory regulations for companies in Germany
- distinguish the terms Corporate Governance, Compliance and Corporate Social Responsibility
- assess regulatory incentives for ethically sound and responsible behaviour
- understand the tasks, objectives and problems of quality and environmental management
- assess the design, opportunities and challenges of management systems
- assess the possibilities and limitations of the different instruments of quality and environmental management
- critically analyze approaches from business practice.

3 Recommended prerequisite for participation

Prerequisites: none
Previous Knowledge: see initial skills

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System)

Supplement to Assessment Methods
Oral/written: Type and duration of exam are announced by the beginning of the course
Written: exam (duration 60 - 90 minutes)
Oral: team or individual exam (duration 15 - 20 minutes per participant)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management

7 Grade bonus compliant to §25 (2)

8 References

	Windbichler, C.; Hueck, A.: Gesellschaftsrecht: Ein Studienbuch, 2017, Bitter, G.; Heim, S.: Gesellschaftsrecht, 2018, Ahsen, A. von; Bradersen, U.; Loske, A.; Marczian, S. (2015): Umweltmanagementsysteme. In: Kaltschmitt, M.; Schebek, L. (Hrsg.): Umweltbewertung für Umweltingenieure, Berlin, Heidelberg, S. 359-402, Baumast, A.; Pape, J. (Hrsg.): Betriebliches Nachhaltigkeitsmanagement, Stuttgart 2013 Further literature will be announced in the lecture.

Courses

Course Nr. 01-42-0006-vu	**Course name** Corporate Governance – statutory requirements for the management and supervision of corporations		
Instructor Prof. Dr. jur. Janine Wendt		**Type** Lecture & Practice	**SWS** 2
Course Nr. 01-14-0010-vu	**Course name** Quality Management and Environmental Management		
Instructor		**Type** Lecture & Practice	**SWS** 2

Module name					
International Trade and Investment / Entrepreneurship					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
01-62-0M02/6	6 CP	180 h	120 h	1	Every Sem.
Language			**Module owner**		
English			Prof. Dr. rer. pol. Volker Nitsch		

1	**Content** International Trade and Investment: Application of economic theory and empirical methods to analyze the international activities of firms. Focus on characterization of firms active in international business and their role in the economy. Analyze firm-level decisions, such as firm structure, product portfolio, quality. Address government policies to promote trade and investment. Economics of Entrepreneurship: Application of microeconomic theory, such as industrial organization and behavioral economics, to analyze business start-ups and their development. Focus on evaluation of the role of entrepreneurs in the macroeconomy, and the microeconomic performance of young businesses. Address the effects of government policies and economic fluctuations on entrepreneurs, as well as the organization and financial structure, development, and allocational decisions of growing entrepreneurial ventures.
2	**Learning objectives / Learning Outcomes** After the courses the students are able to • apply tools and instruments of economic analysis • understand advanced methods of analyzing and modelling economic behavior • assess and analyze complex decision situations • assess the impact and design options of economic policies identify and assess research questions
3	**Recommended prerequisite for participation** Prerequisites: none Previous Knowledge: see initial skills
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Standard Grading System) Supplement to Assessment Methods Oral/written: Type and duration of exam are announced by the beginning of the course Written: exam (duration 60 - 90 minutes) Oral: team or individual exam (duration 15 - 20 minutes per participant)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
7	**Grade bonus compliant to §25 (2)**
8	**References** Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott. 2007. “Firms in International Trade,” Journal of Economic Perspectives. 21 (Summer): 105-130, Acs, Zoltan J. and David B. Audretsch. 2010. Handbook of Entrepreneurship Research. Springer Further literature will be announced during the courses.
Courses	

	Course Nr. 01-62-0007-vu	**Course name** Entrepreneurship		
	Instructor		**Type** Lecture & Practice	**SWS** 2
	Course Nr. 01-62-0005-vu	**Course name** International Trade and Investment		
	Instructor		**Type** Lecture & Practice	**SWS** 2

Module name Master Seminar					
Module Nr. 01-01-0M05	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 150 h	**Duration** 1	**Cycle offered** Every Sem.
Language German			**Module owner**		

1	**Content** Specific topics in a focus area law and economics or informations management.
2	**Learning objectives / Learning Outcomes** After the course/s the students are able to • identify a specific topic in the fields of business studies, economics or law or information management and elaborate it by means of scientific methods. • research, identify and exploit relevant literature (particularly research literature in English). • structure the topic and establish a line of arguments. • evaluate pros and cons in a comprehensible way. • record the results according to scientific criteria. • present the topic to the group and discuss it.
3	**Recommended prerequisite for participation** Background knowledge: see initial skills and defined by indiviudal examiner and announced in advance.
4	**Form of examination** Module Eccompanying Examination: • [01-01-0M01-se] (Technical Examination, Presentation, Standard BWS) Supplement to Assessment Methods Written paper and presentation (participation in discusson)
5	**Grading** Module Eccompanying Examination: • [01-01-0M01-se] (Technical Examination, Presentation, Weighting: 100 %)
6	**Usability of this module** M.Sc. Wirtschaftsingenieurwesen, M.Sc. Wirtschaftsinformatik, M.Sc. Entrepreneurship and Innovation Management, M.Sc. Logistics and Supply Chain Management
7	**Grade bonus compliant to §25 (2)**
8	**References** Bänsch, A.: Wissenschaftliches Arbeiten: Seminar- und Diplomarbeiten Theissen, M.R.: Wissenschaftliches Arbeiten: Technik, Methodik, Form Thomson, W.: A Guide for the Young Economist - Writing and Speaking Effectively about Economics

Courses

Course Nr. 01-01-0M01-se	**Course name** Master Seminar	
Instructor	**Type** Seminar	**SWS** 2

Module name Creating an IT-Start-Up					
Module Nr. 20-00-1016	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr.-Ing. Michael Gösele		

1	**Content** Introduction to methods for the development and implementation of innovative business models. Learning of tools for different process steps. Pratical examples are presented and discussed. Get familiar with the tools while working on a self selected business model. Presentation of the results after each step during the preparation of the business model.
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are able to understand the principle components and the creation of a business plan. They are able to identify and work on the relevant issues for the creation of business plans for innovative business models.
3	**Recommended prerequisite for participation** - Software Engineering - Bachelor Praktikum
4	**Form of examination** Module Eccompanying Examination: • [20-00-1016-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-1016-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Will be given in Lab.

Courses

Course Nr.	Course name		
20-00-1016-pr	Creating an IT-Start-Up		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Michael Gösele		Internship	4

6 Studium Generale

Complete Catalogue of all modules of all departments of the TU Darmstadt (except department 16, 18, and 20) as well as the RMU-studies. Modules for the Studium Generale can be found in a separate module handbook for the Studium Generale.